DNO COMMON NETWORK ASSET INDICES METHODOLOGY

01/04/2021

Health & Criticality - Version 2.1

A common framework of definitions, principles and calculation methodologies, adopted across all GB Distribution Network Operators, for the assessment, forecasting and regulatory reporting of Asset Risk.

VERSION CONTROL

Version No.	Date	Description	Outcome
Draft v3	01/07/2015	Formal Draft Submission to Ofgem	Ofgem Direction requesting changes received 23/10/2015
Draft v4	15/12/2015	Draft amended as instructed	Approved by Ofgem on 01/02/2016
v1.0	01/08/2016	For consultation in accordance with SLC 51 Part I	Implemented for December 2016 NAW and SDRP submissions
v1.1	30/01/2017	For consultation in accordance with SLC 51 Part I – Revision to Oil Filled Cable PoF and Steel Tower PoF & Network Performance CoF	Approved by Ofgem in May 2017 for use during RIIO-ED1 April 2015 – March 2023
v2.0 Draft	01/09/2020	For consultation on draft proposed changes for RIIO-ED2 period and beyond incorporating Long Term Risk	Post consultation report in support
v2.0 Final	03/11/2020	User Acceptance Testing typo fixes, re-ordering tables 222,223 & 224 and refreshed displayed cost table values	
v2.0	01/01/2021	Issued to Ofgem for SSMC	
v2.1	01/04/2021	Minor typos rectified & all reference costs updated to 2020/21 base, including alignment of the time period considered in the derivation of the Long Term Risk to match payback periods considered in the RIIO-ED2 CBA	Approved by Ofgem in April 2021 Published for use during RIIO-ED2 (April 2023 – March 2028)

The Common Network Asset Indices Methodology is subject to approval by Ofgem for the regulatory period to which it applies. Any changes made to the methodology must be directed by Ofgem and recorded in the table above.

ACKNOWLEDGEMENTS

This version of the Common Network Asset Indices Methodology has been compiled by a dedicated Working Group comprising representatives from all six GB DNO Groups and NIE Networks:

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The Working Group has been informed by Ofgem's Safety, Resilience and Reliability Working Group (SRRWG) for RIIO-ED2 development.

PURPOSE OF DOCUMENT

This document sets out a common methodology for assessing condition-based risk for electricity distribution assets. It has been developed by all six GB DNO groups and NIE Networks to meet the regulatory requirements for Network Asset Risk Metrics for RIIO-ED2 (1 April 2023 to 31 March 2028).

The document sets out the overall process for assessing condition-based risk and specifies the parameters, values and conditions to be used. The collective outputs of the assessment, used for regulatory reporting purposes, are known as the Network Asset Indices under the Common Network Asset Indices Methodology. The methodology requires approval from Ofgem and can be amended subject to an agreed change process.

When approved by Ofgem, this methodology will require DNOs to re-align their current processes and practices to this new standard.

Once implemented, DNOs will be required to report annually against the targets set using the methodology to calculate the changes achieved. These reporting requirements are set down in the RIIO-ED2 Regulatory Instructions and Guidance (RIGs).

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1. GLOSSARY

Term	Definition
Ageing Rate	A parameter that describes the rate of deterioration of Asset Health with age.
Ageing Reduction Factor	A factor that slows down the Ageing Rate of older assets.
Asset Category	A generic term to describe a group of asset types where an input, calculation or calibration within the Common Network Asset Indices Methodology is common.
Asset Health	Represents the condition of an asset measured against a common set of condition factors.
Asset Register Category	Groupings of asset type that are used in reporting the asset population in Ofgem's RIIO-ED2 RIGs. Asset Register Categories are used as Asset Categories within this document, where appropriate.
Asset Replacement	An activity defined in Ofgem's RIIO-ED2 Business Plan Data Template – Glossary [Ref. 1] to remove an existing asset(s) and install a new asset.
Average Overall Consequence of Failure	The mean average of the Overall Consequence of Failure for all assets within the same Health Index Asset Category.
Catastrophic Failure	A sudden or total functional failure of an asset (or a subcomponent), from which recovery of the asset (and/ or sub component) is impossible.
Condition-based Functional Failure	The inability of an asset to perform its required function, because of the condition of asset. This includes: • failures disruptive to the supply of electricity; • catastrophic failures of equipment or subcomponents; • failure of an asset to operate (or be operated) when required; and • failure of an asset to perform its rated duty.
Condition Cap	A maximum limit of Health Score, which forms part of a Condition Modifier.
Condition Collar	A minimum limit of Health Score, which forms part of a Condition Modifier.
Condition Factor	A Factor, which forms part of a Condition Modifier.
Condition Input	Result of an observation or test, used to evaluate the health of an asset.
Condition Input Cap	A maximum limit of Health Score associated with a particular Condition Input.
Condition Input Collar	A minimum limit of Health Score associated with a particular Condition Input.
Condition Input Factor	A Factor associated with a particular Condition Input.
Condition Modifier	A Modifier based on a set of observed or measured Condition Inputs.
Consequence Categories	Categories relating to the different areas that may be impacted by asset failure. The categories represent areas where the Consequences of Failure can be separately evaluated.
Consequences Factor	A Factor applied to the Reference Cost of Failure in order to determine the Consequences of Failure of an asset.
Consequences of Failure	The impact of Condition-based Functional Failure of an asset.
Criticality	A generic term to describe the Consequences of Failure of an asset and indicate its importance in the electricity network
Criticality Index	This is a framework for collating information on the Consequences of Failure of distribution assets and for tracking changes over time. The Criticality Index is a comparative measure of Consequence of Failure. For a particular asset, the Criticality Index is provided by:- • the location of the asset within the Criticality Index Bands; and • the Reference Costs of Failure, for the relevant Asset Register Category
Criticality Index Banding Criteria	The criteria used to define the Criticality Index Bands, expressed as a percentage of the Reference Costs of Failure for each Asset Register Category.
Criticality Index Bands	Bandings used for the reporting of the Overall Consequence of Failure for individual assets, relative to the Reference Costs of Failure for assets in the same Asset Register Category.
Current Health Score	The Health Score calculated for an asset that represents the Asset Health at the time (i.e. in the year) of calculation.
Degraded Failure	A functional failure of an asset (or a subcomponent), from which the asset (and/ or sub component) can be restored, but it may not be cost effective to do so.
DGA Test Modifier	A Condition Modifier applied to HV Transformer, EHV Transformer and 132kV Transformer assets, based on the results of dissolved gas analysis.
Duty Factor	A Factor representing the effect that duty has on the Expected Life of an asset.
Expected Life	The time (in years) in an asset's life when it would be expected to first observe significant deterioration (Health Score 5.5), taking into consideration location or duty, in addition to the asset type.
Factor	A multiplication value, varying around unity.
FFA Test Modifier	A Condition Modifier applied to HV Transformer, EHV Transformer and 132kV Transformer assets, based on measurements of furfuraldehyde (FFA) in oil.
Future Health Score	The Health Score(s) calculated for an asset that represents the Asset Health in any year beyond the current year.
Health	A generic term to describe the Asset condition and indicate its level of degradation.

Term	Definition
Health Index	A framework for collating information on the Asset Health of distribution assets. This framework shall enable:- • tracking of changes in Asset Health over time; and • identification of the Probability of Failure associated with the asset condition. For a particular asset, the reported Health Index is provided by the location of the asset within the Health Index Bands.
Health Index Asset Category	Asset categorisations, used within the Network Assets Workbook, for which DNOs have agreed Secondary Deliverables. Health Index Asset Categories are used as Asset Categories within this document, where appropriate.
Health Index Banding Criteria	The criteria used to define the Health Index Bands.
Health Index Bands	Bandings used for the reporting of the Health Indices for individual assets, based on the Probability of Failure indicated by each asset's health and condition.
Health Score	A numerical value representing a measure of Asset Health.
Health Score Cap	A maximum limit applied to the Health Score, associated with a particular condition point.
Health Score Collar	A minimum limit applied to the Health Score, associated with a particular condition point.
Health Score Factor	A Factor based on one or more Condition Modifiers.
Health Score Modifier	A Modifier applied to the Initial Health Score of assets.
Incipient Failure	A functional failure of an asset (or a subcomponent), which if unaddressed may lead to a degraded or catastrophic failure.
Initial Health Score	The Health Score calculated for an asset, based solely on age-based criteria.
Location Factor	A Factor representing the effect that the environment, in which the asset is installed, has on its Expected Life.
Long Term Risk	A monetised value of risk that represents the total discounted value of risk based on the predicted Probability of Failure and Consequence of Failure over the period of 30 years of an asset.
Measured Condition Input	A Condition Input associated with the measured condition of an asset
Methodology	For the purposes of this document, the Methodology means the Common Network Asset Indices Methodology.
Modifier	A value derived from factors, used to modify a base value within the Asset Health calculation.
Network Asset Risk Metric (NARM)	The measure by which Ofgem will measure the effectiveness of the asset intervention programmes as directed in its RIIO-ED2 price control determination.
Network Asset Secondary Deliverables	Secondary Deliverables relating to Asset Health, criticality and risk, as defined for the RIIO-ED1 period in Standard Condition 51 of the electricity distribution licence.
Normal Expected Life	The time (in years) in an asset's life when it would be expected to first observe significant deterioration (Health Score 5.5), based on consideration of the asset type alone.
Observed Condition Input	A Condition Input associated with the observed condition of an asset
Oil Test Modifier	A Condition Modifier applied to HV Transformer, EHV Transformer and 132kV Transformer assets, based on oil test measurements.
Overall Consequence of Failure	The total Consequence of Failure for an asset, taking account of the Consequences of Failure in all Consequence Categories.
Probability of Failure	The likelihood of a Condition-based Functional Failure occurring (per annum).
Reference Costs of Failure	A base evaluation of the Consequences of Failure in a particular Consequence Category.
Refurbishment	A one-off activity, defined in Ofgem's RIIO-ED2 Business Plan Data Template – Glossary [Ref. 1] that is undertaken on an asset that is deemed to be close to end of life or is otherwise not fit for purpose that extends the life of that asset or restores its functionality.
Reliability Collar	A minimum limit of Health Score, which forms part of a Reliability Modifier.
Reliability Factor	A Factor, which forms part of a Reliability Modifier.
Reliability Modifier	A Modifier applied (at individual DNO discretion) to the Current Health Score of assets.
Risk Index	Has the meaning given in Standard Condition 51 of the electricity distribution licence.
Risk Matrix	The 5x4 matrix formed by the Health Index and Criticality Index respectively

2. ACRONYMS

Acronym	Description
AAAC	All Aluminium Alloy Conductors
ACB	Air Circuit Breaker
ACSR	Aluminium Conductor Steel Reinforced
Cad Cu	Cadmium Copper
CCA	Chromated Copper Arsenate
CI	Customer Interruption
CML	Customer Minutes Lost
CMR	Continuous Maximum Rating
CoF	Consequence of Failure
CRC	Charge Restriction Condition
DGA	Dissolved Gas Analysis
DIN	Dangerous Incident Notification
DNO	Distribution Network Operator
DP	Degree of Polymerisation
DPCR5	Distribution Price Control Review for five years from 1 April 2010 to 31 March 2015
DSI	Death or Serious Injury
EHV	Extra High Voltage
ENA	Energy Networks Association
EQ	Equation
ESQCR	Electricity, Safety, Quality and Continuity Regulations 2002
FFA	Furfuraldehyde
FFC	Fluid Filled Cable
GB	Great Britain
GM	Ground Mounted
HI	Health Index
HSE	Health and Safety Executive or Health, Safety and Environment
HM	Her Majesty or His Majesty
HV	High Voltage
ID	Indoor
IIS	Interruption Incentive Scheme
IR	Insulation Resistance
kV	Kilovolt
LV	Low Voltage
LV UGB	Low Voltage Underground Board (Link Box)
LTA	Lost Time Accident
MMI	Maximum and Multiple Increment
MVA	Megavolt Ampere
NaFIRS	National Fault and Interruption Reporting Scheme
NARM	Network Asset Risk Metric
NAW	Network Assets Workbook
NEDeRs	National Equipment Defect Reporting Scheme
OD	Outdoor
Ofgem	Office of Gas and Electricity Markets
OHL	Overhead Line
PM	Pole Mounted
PoF	Probability of Failure
RIG	Regulatory Instructions and Guidance
RIIO	Ofgem's price control framework first implemented in 2013
RIIO-ED1	First price control for Electricity Distribution companies under the RIIO framework from 1 April 2015 to 31 March 2023
RIIO-ED2	Second price control for Electricity Distribution companies under the RIIO framework from 1 April 2023 to 31 March 2028
RMU	Ring Main Unit
SDI	Secondary Deliverable Intervention
SF_6	Sulphur Hexafluoride
SLC	Standard Licence Condition

SOP	Suspension of Operational Practice
VoLL	Value of Lost Load
VSL	Value of Statistical Life
WM	Wall Mounted

3. INTRODUCTION

For RIIO-ED1, which runs from 1 April 2015 to 31 March 2023, Ofgem has introduced regulatory reporting requirements for GB DNOs to report information relating to both Asset Health and criticality. This information is known as the Network Asset Indices, and these provide an indication of the risk of condition-based failure of network assets. These were used as a Network Output Measure, with DNOs targeted to deliver Network Asset Secondary Deliverables that reflected the risk reduction benefit delivered through activities such as asset replacement and refurbishment.

The requirement for reporting of Network Asset Indices was required within Standard Licence Condition 51 for RIIO-ED1. This licence condition also required DNOs to jointly develop a Common Network Asset Indices Methodology, such that DNOs adopted a common approach to the reporting of indices that measure Asset Health and Criticality.

The Common Network Asset Indices Methodology (v1.1) was approved by Ofgem in May 2017, for use in RIIO-ED1.

A revised version of the Common Network Asset Indices Methodology (herein referred to as “the Methodology”) has been developed by DNOs for application in RIIO-ED2 to meet the anticipated changes in regulatory requirements. This revised version also incorporates changes and amendments identified by DNOs based upon the experience gained from implementing the Methodology during RIIO-ED1.

In RIIO-ED2, DNOs will have required network risk outputs relating to Network Asset Risk Metrics (NARM). Network Asset Indices provide the required Network Asset Risk Metrics.

The required network risk outputs relate to the improvement in risk that is delivered by Asset Replacement, as well as some Refurbishment activities. Such activities are referred to as Interventions.

The required network risk outputs will be agreed as part of the RIIO-ED2 determination and are consistent across the 61 Asset Categories by DNOs. Each DNO is required to report on all the required network risk outputs for all 61 Asset Register Categories regardless of whether they manage such assets, by including a nil return where no assets are managed to ensure consistent reporting. Consequently, DNOs are now required to maintain the Common Network Asset Indices Methodology for all Asset Categories where they are to report the required network risk outputs. This methodology covers all the agreed 61 Asset Categories.

3.1 Network Asset Indices Methodology Objectives

For RIIO-ED1, Standard Licence Condition 51 Part D states the following:

The Network Asset Indices Methodology Objectives are that compliance with the Common Network Asset Indices Methodology enables:

a) *the comparative analysis of network asset performance between Distribution Service Providers over time;*
b) *the assessment of the licensee's performance against the Network Asset Secondary Deliverables; and*
c) *the communication of information affecting the Network Asset Secondary Deliverables between the licensee, the Authority and, as appropriate, other interested parties in a transparent manner.*

The Methodology meets these objectives and those anticipated to apply for RIIO-ED2.

The Methodology details the inputs, calculations and calibration parameters to be used in the calculation of Asset Health and criticality. This means that, where the Methodology is applied, a common output shall be determined for a common set of input data. This facilitates use of the output for comparative analysis. For the avoidance of doubt, all values for parameters outlined within this document are fixed and shall be adhered to in the application of the Methodology.

The communication of information relating to the required network risk outputs, and their delivery, shall be through risk matrices (showing Asset Health and criticality). These are required for regulatory reporting purposes. The output from the Methodology will be used for the population of these risk matrices.

3.2 Asset Health and Probability of Failure

Asset Health is a measure of the condition of an asset and the proximity to the end of its useful life. The Methodology includes a common methodology for the calculation of Asset Health for individual assets. This includes:-

i) current Asset Health informed by observed and measured condition factors; and
ii) future Asset Health, using assumptions regarding the likely future deterioration in Asset Health.

In order to take account of future deterioration it is necessary for the Methodology to:-

i) include some age-based elements within the calculation of Asset Health; and
ii) use a continuous Health Score scale for the evaluation of Asset Health.

As the health of an asset deteriorates (i.e. its condition worsens), the likelihood that it will fail due to condition increases.

The Methodology relates Asset Health to the associated probability of condition-based failure (PoF). For each asset type, the Methodology specifies the exact relationship between Health Score and PoF. Therefore, Asset Health can equally be expressed in terms of PoF.

3.3 Consequences of Failure and Asset Criticality

When an asset fails, there will be an associated impact resulting from that failure. For example, there could be a loss of supply to customers, or an injury resulting from a failure. Such impacts are referred to as Consequences of Failure (CoF).

The Methodology includes a common methodology for the evaluation of the likely CoF associated with the condition-based failure of individual assets. Monetised values are determined for all CoF in £ (at 2020/21 prices).

The criticality of an asset is a relative measure of its CoF compared with the Reference Cost of Failures for its asset type.

3.4 Regulatory Reporting of Network Asset Indices

For each asset, the Methodology shall determine:-

i) the PoF (per annum);
ii) a forecast of the PoF (per annum) in any given future year; and
iii) the CoF (£).

associated with condition-based failures. This information is used for the regulatory reporting of the Network Asset Indices for each asset.

The Network Asset Indices comprise three components:-

i) Health Index - which relates to Asset Health and PoF;
ii) Criticality Index - which relates to CoF; and
iii) Risk Index - this is a monetised risk measure, determined from the combination of the Health Index and Criticality Index, which represents the Long Term Risk associated with asset failure and is the present value (£) of the current and future risk associated with a typical asset within the relevant Health Index and Criticality Index Bands.

The Health Index is a framework for collecting information relating to Asset Health and PoF. The Health Index consists of five bandings. Assets are allocated a Health Index Band based on the Health Score that is determined for the individual asset, which can be directly related to its PoF.

The Criticality Index is a framework for collecting information relating to CoF. The Criticality Index consists of four bandings. Assets are allocated to a Criticality Index Band according to the relative magnitude of the CoF of the individual asset compared to a reference value for the relevant Asset Category.

Each reported asset is allocated to the Risk Matrix which consists of a Health Index Band and a Criticality Index Band. The Risk Index for an asset is based on its position in the Risk Matrix. By assigning a typical PoF and degradation assumptions to each Health Index Band, and a typical CoF to each Criticality Index Band, a monetised value of Long Term Risk (i.e. the present value of current and future risk) can be determined.

Separate Risk Matrices are produced to show:-

i) existing asset risk;
ii) asset risk at the end of a price control period without taking into account any impact of planned interventions; and
iii) asset risk at the end of a price control period taking account of planned interventions.

3.5 Hierarchy of Asset Categories

The Methodology applies to many different types of assets (e.g. overhead line conductor, cables, switchgear etc.).

Whilst the Methodology applies the same generic principles in evaluating health and criticality for each asset type, the inputs, calculations and calibrations differ for different types of assets.

For different asset types, this recognises variations in:-

i) the types of Condition-based Functional Failures;
ii) the evaluation of Asset Health; and
iii) the impact of failure.

Within this document the inputs, calculations and calibrations are often specified according to the type of asset. The groupings of assets used for specifying this information are referred to as Asset Categories.

There are two main types of Asset Category used within this document:-

i) Asset Register Category; and
ii) Health Index Asset Category.

The Asset Register Category represents the groupings of asset type that are used in reporting the asset population in Ofgem's RIIO-ED2 RIGs. The Asset Register Category is also used for the annual reporting of Network Asset Indices to Ofgem.

The Health Index Asset Category represents groupings of asset type at a higher level than the Asset Register Category, where common parameters or treatments are applied in the Methodology.

In this document, each Health Index Category is used to describe the inputs, calculations and calibrations that shall apply to assets in the Asset Register Categories shown in Table 1.

TABLE 1: CATEGORISATION OF ASSETS

Health Index Asset Category	Asset Register Category
LV OHL Support	LV Poles
LV UGB	LV UGB
LV Switchgear and Other	LV Board (WM) LV Board (X-type Network) (WM) LV Circuit Breaker LV Pillar (ID) LV Pillar (OD at Substation) LV Pillar (OD not at a Substation)
HV OHL Support - Poles	6.6/11kV Poles 20kV Poles
HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary 20kV CB (GM) Primary
HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary 6.6/11kV RMU 6.6/11kV X-type RMU 6.6/11kV Switch (GM) 20kV CB (GM) Secondary 20kV RMU 20kV Switch (GM)
HV Transformer (GM)	6.6/11kV Transformer (GM) 20kV Transformer (GM)
EHV OHL Support - Poles	33kV Pole 66kV Pole
EHV OHL Fittings	33kV Fittings 66kV Fittings
EHV OHL Conductor (Tower Lines)	33kV OHL (Tower Line) Conductor 66kV OHL (Tower Line) Conductor
EHV OHL Support - Towers	33kV Tower 66kV Tower
EHV UG Cable (Gas)	33kV UG Cable (Gas) 66kV UG Cable (Gas)
EHV UG Cable (Non Pressurised)	33kV UG Cable (Non Pressurised) 66kV UG Cable (Non Pressurised)
EHV UG Cable (Oil)	33kV UG Cable (Oil) 66kV UG Cable (Oil)

Health Index Asset Category	Asset Register Category
Submarine Cables	HV Sub Cable
	EHV Sub Cable 132kV Sub Cable
EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID)(GM) 33kV CB (Air Insulated Busbars)(OD)(GM) 33kV CB (Gas Insulated Busbars)(ID)(GM) 33kV CB (Gas Insulated Busbars)(OD)(GM) 33kV RMU 33kV Switch (GM) 66kV CB (Air Insulated Busbars)(ID)(GM) 66kV CB (Air Insulated Busbars)(OD)(GM) 66kV CB (Gas Insulated Busbars)(ID)(GM) 66kV CB (Gas Insulated Busbars)(OD)(GM)
EHV Transformer	33kV Transformer (GM) 66kV Transformer (GM)
132kV OHL Fittings	132kV Fittings
132kV OHL Conductor (Tower Lines)	132kV OHL (Tower Line) Conductor
132kV OHL Support - Tower	132kV Tower
132kV UG Cable (Gas)	132kV UG Cable (Gas)
132kV UG Cable (Non Pressurised)	132kV UG Cable (Non Pressurised)
132kV UG Cable (Oil)	132kV UG Cable (Oil)
132kV Switchgear	132kV CB (Air Insulated Busbars)(ID)(GM) 132kV CB (Air Insulated Busbars)(OD)(GM) 132kV CB (Gas Insulated Busbars)(ID)(GM) 132kV CB (Gas Insulated Busbars)(OD)(GM)
132kV Transformer	132kV Transformer (GM)

Within this document several generic terms are used to refer to higher level groupings of assets. The mapping of these generic terms to Health Index Asset Category is shown in Table 2.

TABLE 2: GENERIC TERMS FOR ASSETS

Generic Term		Health Index Asset Category
Cable	Pressurised Cable	EHV UG Cable (Oil)
		EHV UG Cable (Gas)
		132kV UG Cable (Oil)
		132kV UG Cable (Gas)
	Non Pressurised Cable	EHV UG Cable (Non Pressurised)
		132kV UG Cable (Non Pressurised)
		Submarine Cables
Switchgear		LV Switchgear and Other
		LV UGB
		HV Switchgear (GM) - Distribution
		HV Switchgear (GM) - Primary
		EHV Switchgear (GM)
		132kV Switchgear

Generic Term		Health Index Asset Category
Transformers	HV Transformer	HV Transformer (GM)
	Primary & Grid (or EHV & 132kV) Transformers	EHV Transformer
		132kV Transformer
Overhead Line	Poles	LV OHL Support
		EHV OHL Support - Poles
		HV OHL Support - Poles
	Towers	EHV OHL Support - Towers
		132kV OHL Support - Towers
	Fittings	EHV OHL Fittings
		132kV OHL Fittings
	OHL Conductor	EHV OHL Conductor (Tower Lines)
		132kV OHL Conductor (Tower Lines)

In some calibration tables, asset subcomponents are identified. Where not explicitly stated the calibration of the Health Index Asset Category applies to all subcomponents.

Defined Asset Register Categories not covered by the Methodology are shown in Table 3.

TABLE 3: EXCLUDED ASSET REGISTER CATEGORIES

Asset Register Category	Voltage
LV Main (OHL) Conductor	LV
LV Service (OHL)	LV
LV Main (UG Consac)	LV
LV Main (UG Plastic)	LV
LV Main (UG Paper)	LV
Rising & Lateral Mains	LV
LV Service (UG)	LV
LV Service associated with RLM	LV
Cut Out (Metered)	LV
LV Transformers/Regulators	LV
6.6/11kV OHL (Conventional Conductor)	HV
6.6/11kV OHL (BLX or similar Conductor)	HV
20kV OHL (Conventional Conductor)	HV
20kV OHL (BLX or similar Conductor)	HV
6.6/11kV UG Cable	HV
20kV UG Cable	HV
6.6/11kV CB (PM)	HV
6.6/11kV Switch (PM)	HV
6.6/11kV Switchgear - Other (PM)	HV
20kV CB (PM)	HV
20kV Switch (PM)	HV
20kV Switchgear - Other (PM)	HV
6.6/11kV Transformer (PM)	HV
20kV Transformer (PM)	HV
Batteries at GM HV Substations	HV
33kV OHL (Pole Line) Conductor	EHV
66kV OHL (Pole Line) Conductor	EHV
33kV Switchgear - Other	EHV
33kV Switch (PM)	EHV
66kV Switchgear - Other	EHV

Asset Register Category	Voltage
33kV Transformer (PM)	EHV
Batteries at 33kV Substations	EHV
Batteries at 66kV Substations	EHV
132kV OHL (Pole Line) Conductor	132kV
132kV Pole	132kV
132kV Switchgear - Other	132kV
Batteries at 132kV Substations	132kV
Pilot Wire Overhead	Other
Pilot Wire Underground	Other
Cable Tunnel (DNO owned)	Other
Cable Bridge (DNO owned)	Other
Electrical Energy Storage	Other

4. OVERVIEW OF COMMON NETWORK ASSET INDICES METHODOLOGY

This section gives a high-level overview of the Common Network Asset Indices Methodology. Detailed explanations are given in Sections 6 and 7, with accompanying worked examples in Appendix F.

4.1 Key Outputs

The two key outputs from the Methodology are:-

i) an evaluation of PoF (the likelihood of condition-based failure per annum) for individual assets; and
ii) an evaluation of the CoF associated with condition-based failures for individual assets (i.e. the impact of a failure, expressed as a monetised value, in £).

The risk of condition-based failure, associated with an individual asset, is the product of the PoF and the CoF. Therefore, the two key outputs from the Methodology, when used together, provide information relating to condition-based risk.

PoF and CoF are calculated for all individual assets within those Health Index Asset Categories where a DNO has agreed Network Asset Secondary Deliverables. An overview of the calculation process is shown in Figure 1.

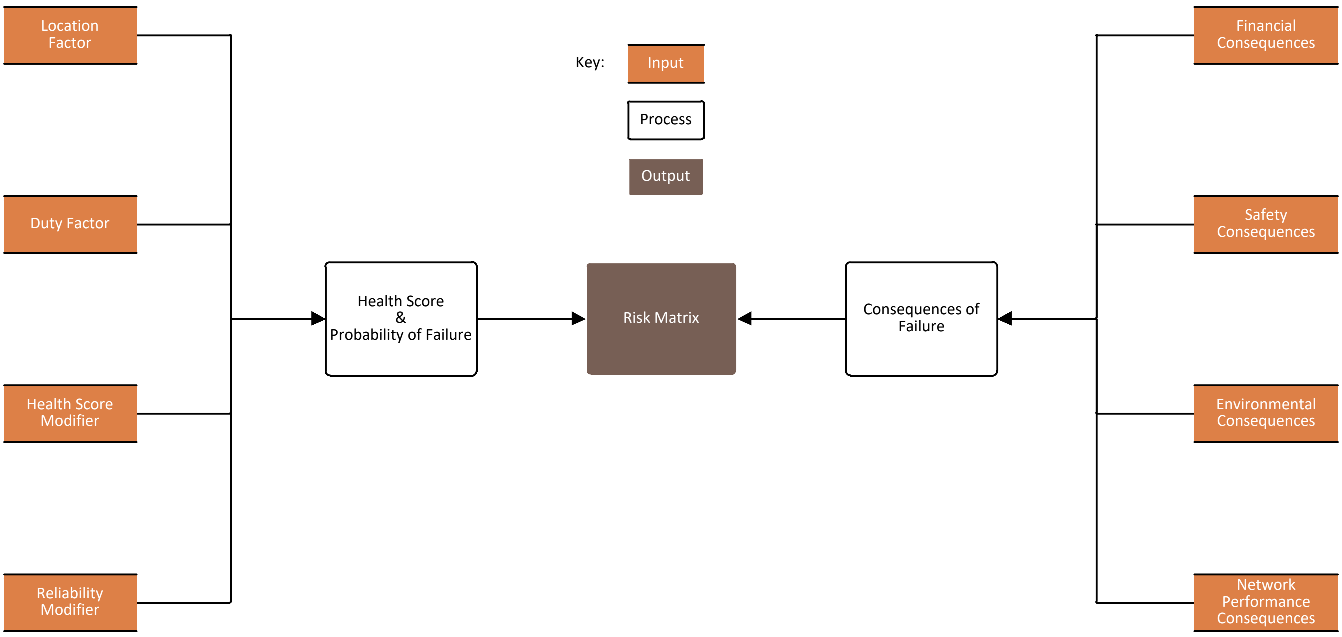

FIGURE 1: PROCESS OVERVIEW

The regulatory reporting framework for Network Asset Indices comprises three components:-

i) the Health Index, summarised in five bands HI1-5;
ii) the Criticality Index, summarised in four bands C1-4; and
iii) the Risk Index.

For regulatory reporting purposes, individual assets are assigned to a Health Index Band based on the Health Score that has been determined for the asset under the Methodology.

The evaluation of PoF is dependent on:-

i) firstly, assessing Asset Health; and
ii) then deriving PoF from Asset Health.

Assets are assigned to a Criticality Index Band based on the relative magnitude of their Overall CoF, when compared to a common reference value for the Asset Register Category (the Reference Costs of Failure).

The Risk Index is a monetised risk measure that is calculated from the reported Health Index and Criticality Index information by assigning each cell in the Risk Matrix a reference risk value in £. Given the assessments above, an individual asset can be assigned a position within the Risk Matrix for that asset type.

The allocation of assets to Health Index Bands and Criticality Index Bands, and derivation of Risk Index, is described further in Section 5.

The regulatory reporting of Network Asset Indices includes the reporting of forecast future Health Index and Criticality Index for each asset, as well as the current position. This requires that the Methodology includes assessment of:-

i) current PoF and CoF; and
ii) forecast future PoF and CoF (including the assessment of changes arising from Interventions). This requires a common assessment of deterioration and a consistent view of which actions impact health and/or criticality.

4.2 Definition of Failure

The evaluation of PoF and CoF within the Methodology may be viewed as two separate distinct calculations. However, they are both based on consideration of the same set of condition-based failure modes (i.e. the same definition of what is a failure) to ensure the same set of potential events is being considered in the assessment of probabilities and consequences.

The Methodology considers Functional Failures in the derivation of PoF and CoF. These relate to the inability of an asset to adequately perform its intended function and therefore are not solely limited to failures that result in an interruption to supply.

Functional failures have been split into three sub-categories (Functional Failure Types), these are described as follows:

TABLE 4: DESCRIPTION OF FUNCTIONAL FAILURE TYPES

Functional Failure Type	Description
Catastrophic	A sudden and total failure from which recovery of the asset (and or sub component) is not feasible.
Degraded	A significant failure associated with advanced degradation.
Incipient	A minor failure associated with early stage degradation.

The Functional Failures considered in the Methodology are defined for each Asset Category, in Appendix A. These relate only to Functional Failures directly resulting from the condition of the asset itself. Failures of function due to third party activities are not included.

4.3 Evaluation of Current Asset Health and Probability of Failure

4.3.1 Overview

This section describes how current Asset Health is calculated and used to derive an associated PoF. Worked examples of this calculation can be found in Appendix F.

4.3.2 Current Health Score

The current health of an asset is represented by a Health Score (the Current Health Score) using a continuous scale between 0.5 and 10.

A value of 0.5 on this scale represents an asset where the health is the same as would be expected for a new asset. A Health Score of 5.5 represents the point in an asset's life beyond which significant deterioration may begin to be observed. This is where the PoF of the asset is approximately double that of a new asset. A Health Score of 10 represents an asset in extremely poor condition, where the PoF is 10 times that of a new asset.

The Current Health Score for an individual asset is derived from information relating to:-

i) the age of the asset;
ii) the Normal Expected Life for an asset of its type;
iii) factors relating to aspects of the environment in which the asset is installed that may impact on its Expected Life (Location Factors);
iv) factors relating to the usage of the asset at its specific location that may impact on its Expected Life (Duty Factors);
v) factors relating to the observed condition of the asset (Observed Condition Inputs);
vi) factors relating to the condition/health of the asset determined by measurements, tests or functional checks (Measured Condition Inputs); and
vii) a factor relating to generic reliability issues associated with the individual make and type of an asset (Reliability Modifier).

The calculation of Current Health Score is performed in two main steps:-

i) calculation of an initial age-based Health Score (the Initial Health Score) using an age-based degradation model; then
ii) modification of the Initial Health Score using:-
    - known condition information for the asset; and
    - a Reliability Modifier, if appropriate.

These two steps are described in more detail below:-

i) <u>Calculation of the Initial Health Score</u>

The Initial Health Score is calculated from the age of the asset and its Expected Life. The Expected Life for the asset is the Normal Expected Life for an asset of its type, adjusted to take account of the Location Factors and Duty Factors relating to the individual asset's location and usage.

A generic exponential relationship between age and health is used to determine the Initial Health Score. The shape of the exponential curve is dependent on the Expected Life of the asset.

The Initial Health Score is capped at a value of 5.5, so that an asset is not assigned a Current Health Score that implies that it has reached the end of its useful life purely on the basis of its age.

The Methodology defines the calculation of Initial Health Score for all Asset Categories. This includes definitions of the Location Factor and Duty Factor to be applied, and their calibration parameters. Therefore, an asset in any DNO Licence Area with the same age, type, location and duty attributes will be assigned the same Initial Health Score using the Methodology.

The steps to calculate the Initial Health Score are detailed in Sections 6.1.3 to 6.1.6.

ii) <u>Modification of the Initial Health Score</u>

The Current Health Score is determined by application of a Health Score Modifier, and separate Reliability Modifier, to the Initial Health Score.

A Health Score Modifier is determined for each individual asset, using information relating to the asset's condition. This information can be broadly categorised as either:-

- Observed Condition Inputs; or
- Measured Condition Inputs.

Observed Condition Inputs relate to condition information that can be gathered by the inspection of an asset. However, it is not always possible to gather observed condition data without undertaking intrusive inspection.

Alternatively, diagnostic tests, measurements or functional checks may be undertaken to ascertain the health of the asset. Measured Condition Inputs relate to condition information that is collected in this way.

The Methodology defines various Observed Condition Inputs and Measured Condition Inputs that can be used to determine the Health Score Modifier for an asset, including their calibration parameters.

These Condition Inputs and the methodology for determining the values for the Health Score Modifier are detailed in Sections 6.7 to 6.13.

The application of the Health Score Modifier to the Initial Health Score is described in Section 6.1.7.

It may be appropriate to apply a Reliability Modifier in the derivation of the Current Health Score (as detailed in Section 6.14). This is applied to take account of assets, where in individual DNO or industry experience, there are asset type or make issues leading to material differences in the reliability of the asset. Where a DNO applies a Reliability Modifier to an asset, this shall be described within their own Network Asset Indices Methodology.

In recognition that different inspection and assessment approaches exist between DNOs, there is no requirement for data to be collected to apply all the Condition Inputs specified within the Methodology.

Where DNOs have collected the same condition information for an asset, application of the Methodology shall result in the same Health Score Modifier values being determined for the asset. As there is commonality in the derivation of the Initial Health Score, an asset in any DNO with the same age, type, location, duty and collected condition information will be assigned the same Current Health Score using the Methodology, except where a Reliability Modifier is applied.

The Reliability Modifier is applied at the final stage of the calculation of Current Health Score so that its effect on the Current Health Score can be directly observed.

The Current Health Score is capped at a value of 10.

4.3.3 Current Probability of Failure

For each Asset Category, the relationship between Health Score and PoF is defined within the Methodology. The current PoF is derived from the Current Health Score. This is described in Section 6.

As this relationship and its calibration values are defined, the PoF for assets will be identical where the Health Score and Asset Category are the same. This means that an asset in the same health is considered to have the same likelihood of condition-based failure irrespective of which DNO it is installed in.

4.4 Evaluation of Future Asset Health and Probability of Failure

4.4.1 Overview

The evaluation of future PoF assumes that as an asset ages in the future then its health will deteriorate and consequently the PoF will increase. This is performed by evaluating the forecast future Asset Health for the asset and then deriving the associated PoF.

4.4.2 Future Health Score

The Future Health Score is derived using similar age-based deterioration assumptions to those used in the calculation of the Initial Health Score. It is derived by forecasting forwards from the Current Health Score using a simple exponential relationship as detailed in Section 6.1.10.

The rate of deterioration used for forecasting the Future Health Score is informed by the amount of deterioration in Asset Health that has already been observed for the asset from its current state (i.e. Current Health Score) and age. This is detailed in Section 6.1.8.

The Future Health Score is capped at a value of 15, which is higher than the cap that is applied to the Current Health Score. This is to enable modelling of further deterioration of all assets.

4.4.3 Future Probability of Failure

The calculation of future PoF uses the same relationship between Health Score and PoF that is used in the derivation of the current PoF (see Section 4.3.3 above).

The future PoF for an asset is derived by applying this relationship to the Future Health Score.

4.4.4 Interventions

The reporting of Health Index and Criticality Index requires the effect of investment activities that are aimed at managing the risk of condition-based failures to be evaluated. This is described in Section 6.1.11.

4.5 Evaluation of Consequences of Failure

The Methodology separately evaluates the CoF for each individual asset, in four specified Consequence Categories:-

i) Financial (incorporating repair & replacement costs);
ii) Safety;
iii) Environmental; and
iv) Network Performance.

A monetised value in £ (at 2020/21 prices) is assessed for each of these Consequence Categories. The Overall Consequence of Failure for an asset can therefore be derived by the summation of the CoF in each of these categories. These represent the impact of a failure and the societal cost of that impact.

The methodology for the calculation of CoF in each of the Consequence Categories is based on the use of Reference Costs of Failure. These are defined in Section 7 of the Methodology and are common, using accepted societal costs where available.

For an individual asset, the CoF associated with the asset is driven by the localised situation of the asset. For example, the Network Performance impact will be driven by the number of customers, or amount of load, that is affected by failure of the asset. Similarly, the environmental impact may be dependent on the proximity of the asset to an environmentally sensitive area (such as a watercourse).

To reflect this, the CoF associated with each individual asset is determined by application of asset-specific modifying factors to the appropriate reference cost. These factors represent the variation to the reference costs that results from the localised situation of the individual asset.

The Methodology specifies the asset-specific factors that shall be applied in the derivation of the CoF and also the associated calibration values. As a result, application of the Methodology results in a consistent evaluation of the CoF, across DNOs, which also reflects the localised situation of individual assets.

Section 7 provides details for the methodology for determining CoF. Worked examples of this calculation can be found in Appendix F.

4.6 Assimilating innovation in operation and maintenance

The Methodology has been designed such that it can seamlessly incorporate future innovation in operation and maintenance. Innovation in condition monitoring in particular has been a key driver in the development of health scores across electricity distribution over the last two decades. We envisage continual development and improvement in this field.

There are two key mechanisms that allow new developments to be assimilated:-

i) Much innovation consists of improving ways of understanding existing aspects of DNO assets better. Input factors have therefore been designed so that they are broad enough in description to allow the mapping of new techniques to existing factors. For example, partial discharge is one of the measured Condition Modifiers in many Asset Categories, but how partial discharge is measured is non-prescribed. As better techniques are developed, they can be used without requiring revision of the Methodology.

ii) Occasionally innovation might produce a new technology which would allow a brand-new Condition Modifier to be used. In such an instance, the agreed change process with Ofgem would be invoked to determine the appropriate weightings for inclusion of the new factor. The Methodology combines multiple Condition Inputs using an approach that ensures that such a change is easy to implement and also that it can be incorporated into the Methodology without causing knock-on effects on the existing set of Modifiers.

Another area of innovation is in the development of new interventions. The process of scoring assets post intervention is described in Appendix C to this document which is in turn governed under the RIGs Annex A and referenced in the RIIO-ED2 Business Plan Data Template – Glossary [Ref. 1]. Subject to any change in the RIGs, the agreed change process with Ofgem would apply to enable instruction as to how the change should be applied to Health Scores.

5. RISK

5.1 Overview

This section covers the methodology which will be applied by DNOs to calculate the PoF and CoF of an asset, as well as the banding for mapping these outputs to the Health Index and Criticality Index within the Risk Matrix for each Asset Register Category.

5.2 Risk Evaluation

For each asset, the Methodology determines:-

i) the current PoF (per annum);
ii) a forecast of the PoF (per annum) in any given future year; and
iii) the Overall CoF (£).

For either the current year, or any given future year, the risk of failure associated with each individual asset can be evaluated in £ (at 2020/21 prices) from the product of the PoF (for the relevant year) and the Overall Consequence of Failure values for that asset. However, the asset-specific actual risk of failure is not used for regulatory reporting. Instead, a typical value of monetised risk, the Risk Index, is derived from the reported Health Index and Criticality Index for each asset. The Risk Index represents the Long Term Risk associated with asset failure and is the present value (£) of the current and future risk associated with a typical asset within the relevant Health Index and Criticality Index Bands[1]. This is explained further in Section 5.5.

5.3 Representation of Assets Within Risk Matrices

For the regulatory reporting of Asset Health and criticality, Risk Matrices are used. These show the population of assets within a given Asset Register Category that have the same Health Index and Criticality Index. This is illustrated in Figure 2.

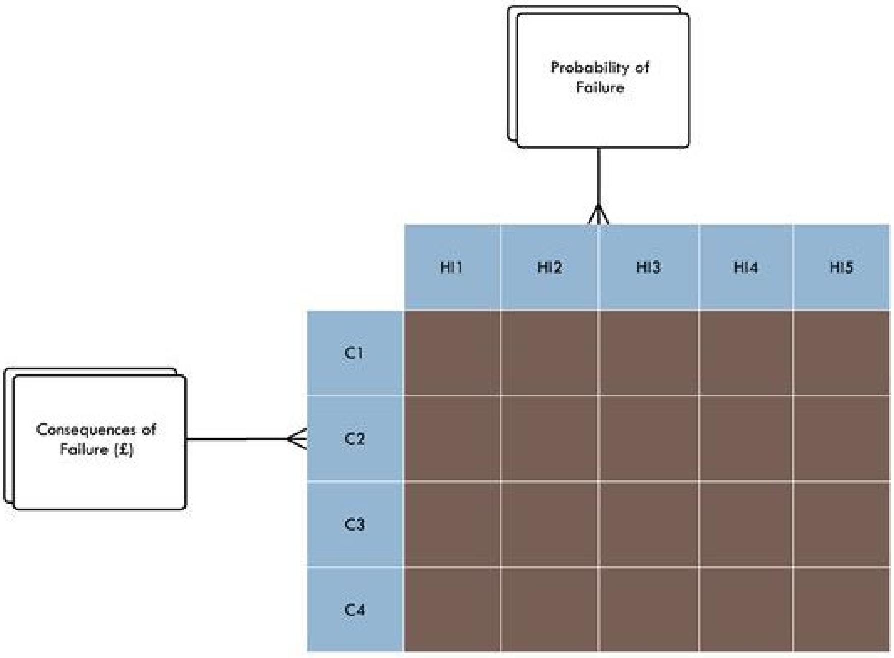

FIGURE 2: RISK REPORTING MATRICES

[1] In CNAIM v1.1, the Risk Index was related to the risk of failure in a given year and did not consider the value of risk associated with future years within the monetised risk measure.

The Methodology evaluates the current health of an asset using a Health Score with a continuous scale between 0.5 and 10 (this scale is extended up to 15 for the forecasting of future health). The relationship between this Health Score and PoF is defined by the Methodology and is explained in Section 6. The Health Index subsequently groups assets into one of the five bandings (HI1 to HI5) based on their Health Score as shown in Table *5*.

TABLE 5: HEALTH INDEX BANDING CRITERIA

Health Index Band	Health Index Banding Criteria	
	Lower Limit of Health Score	Upper Limit of Health Score
HI1	≥0.5	<3
HI2	≥3	<5.5
HI3	≥5.5	<6.5
HI4	≥6.5	<8
HI5	≥8	≤15

These Health Index Bands are subsequently translated to PoF values. Figure 3 illustrates where the Health Index Bands lie on a typical Asset Health / PoF curve.

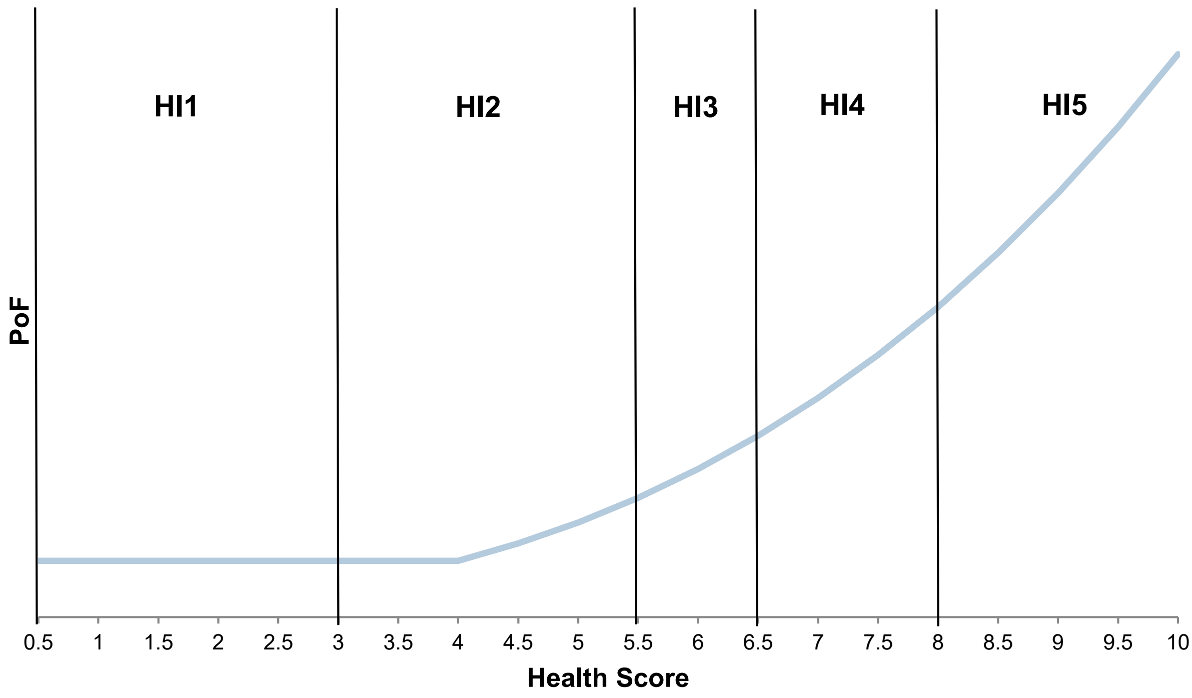

FIGURE 3: HI BANDING

The Criticality Index groups assets into bandings based on their CoF. Each asset shall be placed in a Criticality Index Band, based on the relative magnitude of the Overall CoF of the asset, compared to the Reference Costs of Failure that are used in the determination of CoF for all assets in the Asset Register Category. The Reference Costs of Failure are defined in Section 7 of the Methodology and are common for all DNOs.

There are four Criticality Index Bands:-

i) C1 - 'Low' criticality
ii) C2 - 'Average' criticality

iii) C3 - 'High' criticality
iv) C4 - 'Very High' criticality

The 'C2' Criticality Index Band represents assets where the Overall CoF are approximately the same as the Reference Costs of Failure for the Asset Register Category.

For each Asset Register Category, the Criticality Index Banding Criteria are expressed as a percentage of the Reference Costs of Failure for the Asset Register Category. These are shown in Table 6.

TABLE 6: CRITICALITY INDEX BANDING CRITERIA

Criticality Index Band	Criticality Index Banding Criteria	
	Lower Limit of Overall CoF (as % of Reference Costs of Failure for the Asset Register Category)	Upper Limit of Overall CoF (as % of Reference Costs of Failure for the Asset Register Category)
C1	-	< 75%
C2	≥ 75%	< 125%
C3	≥ 125%	< 200%
C4	≥ 200%	-

Using the approach outlined above, the outputs from the Methodology can facilitate population of Risk Matrices for the regulatory reporting of the Health Index and Criticality Index for each asset.

5.4 Evaluating In-Year Risk Using Risk Matrices

By assigning:-

i) a typical value of PoF (per annum) to all assets within the same Health Index Band (for a given Asset Register Category); and
ii) a typical value of Consequence of Failure to all assets within the same Criticality Index Band (for a given Asset Register Category)

it is possible for the risk of failure (per annum) associated with each asset to be approximated by reference to its position within the Risk Matrix. This provides an evaluation of the 'in-year' risk of failure of an asset, enabling the asset risk at a point in time to be quantified.

The typical value of PoF is calculated from a typical Health Score for each Health Index Band using the relationship defined in Section 6.1.1 of the Methodology. Table 7 provides the input data for the derivation of typical PoF values.

TABLE 7: HEALTH SCORE USED TO DERIVE TYPICAL POF

Health Index Band	Health Score to be used to derive Typical PoF
HI1	1.23
HI2	4.25
HI3	6.00
HI4	7.25
HI5	9.00

For the HI2 – HI4 bands, the use of the midpoint Health Score to derive the Average PoF produces a reasonable approximation of the average value that would be observed for a uniform distribution of assets within that Health Index Band. The typical Health Scores for the HI1 and HI5 bands take account of the expected typical distribution of assets within these bands.

The resulting typical PoF weightings for each Health Index Band, for each Asset Register Category, can be found in Section E.2 of Appendix E.
For each Criticality Index Band, the typical value of Consequence of Failure is determined by application of the percentage factors shown in Table 8, below, to the Reference Costs of Failure (see Section 7 of the Methodology) for the relevant Asset Register Category.

TABLE 8: PERCENTAGE FACTORS USED TO DERIVE TYPICAL CONSEQUENCES OF FAILURE

Criticality Index Band	Percentage Factor to Be Applied to The Reference Costs of Failure
C1	70%
C2	100%
C3	150%
C4	250%

The resulting typical values of Consequence of Failure for each Criticality Index Band, for each Asset Register Category, can be found in Section E.1 of Appendix E.

The 'in-year' risk of failure of an asset (£ at 2020/21 prices) is the product of the typical PoF for its Health Index Band and the typical Consequences of Failure for its Criticality Band. The resulting value of 'in-year' risk of failure for each Health Index/ Criticality Index combination, for each Asset Register Category, can be found in Section E.2 of Appendix E.

During RIIO-ED1, 'in-year' risk was used in regulatory reporting for defining targets for, and measuring performance, against Network Asset Secondary Deliverables.

For RIIO-ED2, the measure of risk used for regulatory processes shall be based on consideration of the future risk associated with an asset and consequently a long term measure of risk shall be used for defining targets and measuring delivery against the RIIO-ED2 NARM outputs. This is described in Section 5.5 of the Methodology.

5.5 Evaluating Long Term Risk Using Risk Matrices

DNOs' investment decisions do not just address the asset risk in the current year, but also address the cumulative risk across all future years. It is therefore important to evaluate the asset risk that is forecasted for future years when considering the justification for investment decisions that are aimed at managing the condition-based risk associated with assets. This enables the impact of interventions upon the Long Term Risk of the asset to be considered against the cost of intervention. For the cumulative risk over future years to be compared with the cost of intervention, it is necessary to quantify the future risk in terms of its present value (i.e. in discounted terms). The methodology calculates this risk which is termed as the Long Term Risk.

Recognising that the risk in future years needs to be considered when evaluating the outcome of interventions, for RIIO-ED2, a long term measure of risk shall be used to define the targets for the NARM and measure delivery against these targets. The Long Term Risk measure shall therefore provide the Risk Index for regulatory reporting.

The Methodology can be used to determine the risk associated with an asset in the current year and forecast how the risk in each subsequent individual future year will be affected by degradation of the asset. This is achieved by considering how PoF will change in future years over a given period. The calculation of PoF, including PoF in each future year, is described in Section 6 of the Methodology. A discount factor can be applied to the risk calculated for each future year, so that the risk in each year can be considered at its present value. This can then be summated for each year across the future period under consideration to determine the present value of future (whole life) risk in the period.

By treating Consequence of Failure as a constant, the present value of future Long Term Risk can be expressed as shown in EQ. 1:-

$$\textit{Present value of future risk}_{0-n} = \left[\sum_{i=0}^{n} \left(PoF_i \times (1+\mathrm{r})^{-i}\right)\right] \times \mathrm{CoF}$$

EQ. 1

Where:

- *i = number of years subsequent to current year (where current year is year 0)*
- *n = number of future years considered;*
- *PoF_i = the expected number of functional failures in year i;*
- *CoF = the Consequence of Failure (£ at 2020/21 prices); and*
- *r is the discount rate.*

It is appropriate when considering future risk of an asset, to consider the Consequence of Failure to be a constant, as changes to the factors that influence the Consequence of Failure, for an individual asset, are infrequent and cannot be reasonably predicted.

This equation separates the present value of future Long Term Risk into two components:-

- Consequence of Failure; and
- a 'cumulative discounted PoF' term, which represents the POF and the financial discounting elements of the equation for present value of future Long Term Risk (EQ. 2) such that:-

$$\textit{Cumulative discounted PoF}_{0-n} = \left[\sum_{i=0}^{n} \left(PoF_i \times (1+\mathrm{r})^{-i}\right)\right]$$

EQ. 2

By assigning:-

i) a typical value of 'cumulative discounted PoF' to all assets within the same Health Index Band (for a given Asset Register Category); and
ii) a typical value of Consequence of Failure to all assets within the same Criticality Index Band (for a given Asset Register Category),

it is possible for the Long Term Risk associated with each asset to be approximated by reference to its position within the Risk Matrix. The Risk Index for each Health Index / Criticality Index Band is the product of the typical 'cumulative discounted PoF' for the Health Index Band and typical Consequence of Failure for the Criticality Index Band.

For each Asset Register Category, a typical value of 'cumulative discounted PoF' can be assigned to each Health Index Band by considering all assets within the same Health Index Band (for the given Asset Register Category) to have:-

i) the same typical value of Health Score for the current year (year 0); and
ii) the same typical value of Forecast Ageing Rate.

From the typical value of current year Health Score and typical Forecast Ageing Rate, the Future Health Score for each future year can be evaluated as described in Section 6.1.10 of the Methodology and the associated value of PoF determined using the relationship defined in Section 6.1.1 of the Methodology.

The typical value of current year Health Score for each Health Index Band (for all Asset Register Categories) shall be the same value as shown in Table 7 in Section 5.4 for the determination of Typical PoF weightings.

The typical Forecast Ageing Rates for each Asset Register Category, which are used in the determination of the Future Health Scores for each future year, are shown in Section E.3 of Appendix E. These are the same as the Initial Ageing Rate that would be determined, using the approach shown in Section 6.1.5 of the Methodology, if the Expected Life of the asset was considered as being the same as a typical Normal Expected Life for the Asset Register Category.

In determining the 'cumulative discounted PoF', the current year PoF and future PoF for a period of 30 years shall be considered. A discount rate of 3.5% shall be applied for each year. This discounting rate is consistent with the Social Time Preference Rate in the HM Treasury Green Book (2020) [Ref. 11] and Ofgem CBA methodology for RIIO-ED2.

For each Asset Register Category, the discounted PoF for each year, of the 30 year period, is summated to create a typical 'cumulative discounted PoF' for each Health Index Band. The resulting values of typical 'cumulative discounted PoF' are shown in Section E.3 of Appendix E. These are the values used to multiply out the Risk Matrices.

For each Criticality Index Band, the typical value of Consequence of Failure is determined by application of the percentage factors to the Reference Costs of Failure, as described in Section 5.4 of the Methodology. The resulting typical values of Consequence of Failure for each Criticality Index Band, for each Asset Register Category, can be found in Section E.1 of Appendix E. These are the values used to multiply out the Risk Matrices.

The Risk Index (£ at 2020/21 prices) is determined from the product of the relevant typical 'cumulative discounted PoF' and typical Consequences of Failure for each Health Index Band/ Criticality Index Band combination, for each Asset Register Category, and can be found in Section E.3 of Appendix E.

The monetisation of risk is consistent across all Asset Register Categories and therefore enables risk trading within and across Asset Register Categories.

6. PROBABILITY OF FAILURE

6.1 PoF Calculation (General)

6.1.1 Overview

The Health Index (HI) is derived from the Health Score and PoF. The PoF of an asset is a function of the asset's Health Score, with the Health Score being a function of Normal Expected Life, location, duty, reliability, observed condition and measured condition.

For the majority of assets, a single Health Score is calculated, which is then converted into a PoF. However, for HV, EHV and 132kV Transformers and steel Towers, it is necessary to calculate a Health Score for each component and then combine these into an overall Health Score. These multi-component assets are special cases which are covered in more detail in Sections 6.2 and 6.3. Figure 4 shows the process to be followed to calculate the PoF of an asset (or component):-

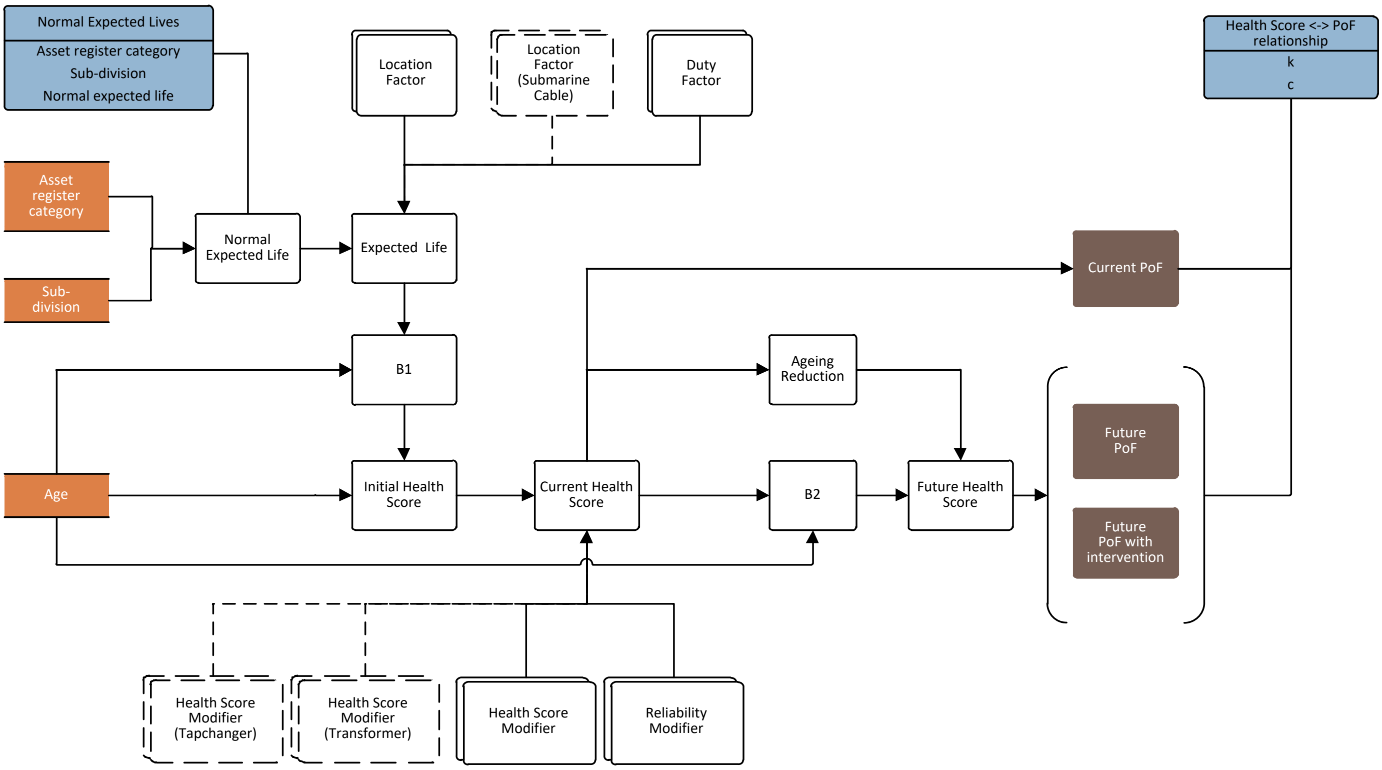

FIGURE 4: PROBABILITY OF FAILURE

The PoF per annum shall be calculated using the cubic curve shown in EQ. 3. This is based on the first three terms of the Taylor series for an exponential function. This implementation has the benefit of being able to describe a situation where the PoF rises more rapidly as asset health degrades, but at a more controlled rate than a full exponential function would describe.

$$\mathrm{PoF} = \mathrm{K} \times \left[1 + (\mathrm{C} \times \mathrm{H}) + \frac{(\mathrm{C} \times \mathrm{H})^2}{2!} + \frac{(\mathrm{C} \times \mathrm{H})^3}{3!}\right]$$

EQ. 3

Where:

- *H is a variable equal to Health Score (Current or Future), unless Health Score ≤ 4 then H = 4*
- *K and C are constants*

The constants and variables in the above equation are described in Section 6.1.2.

6.1.2 K-Value, C-Value and Constants in PoF

A generic and common PoF curve as described by EQ. 3 is used to define the relationship between asset Health Score and PoF. The curve is one commonly used in reliability theory. It shows constant PoF for low values of Health Score and an exponential increase in PoF for higher values of Health Score, representing where increasing health degradation results in an escalating likelihood of failure. The shape of a typical PoF curve can be seen in Figure 3.

For a common curve, the parameters used to construct the curve need to be common. The common parameters are the C-Value that defines the shape of the curve, the K-Value that scales the PoF to a failure rate, and the Health Score limit at which there is a transition from constant PoF to an exponential relationship. The values for the C-Values, the K-Values and the constant Health Score limit are shown in Table 21 in Appendix B.

The C-Value is the same for all Asset Categories and has been selected such that the PoF for an asset in the worst state of health is ten times higher than the PoF of a new asset.

The Health Score limit represents the point at which there starts to be a direct relationship between the Health Score and an increasing PoF. The PoF associated with Health Scores below this limit relate to installation issues or random events.

The K-Value for each Asset Category has been derived by consideration of:-

i) the observed number of Functional Failures per annum, considering the number of failures in each of the three failure modes that are identified in Appendix A (i.e. Incipient Failures, Degraded Failures and Catastrophic Failures for each Asset Category);
ii) the Health Index distribution for the asset population; and
iii) volumes of assets within the population.

By calibrating K using the overall number of Functional Failures across all the failure modes, the resulting PoF represents the combined PoF for all considered failure modes.

The calibration of K has been undertaken using data representing the national population of assets and ensures that in each Asset Category the total GB expected number of Functional Failures, derived from the relative PoF contribution of every asset in the GB Health Index distribution, matches the number of GB Functional Failures.

For linear assets (Cables and Tower Conductor) the K-Value was calculated using the GB number of Functional Failures per kilometre per annum. The PoF reported for these Asset Categories is therefore the PoF per km per annum. The number of kilometres reported per Health Index Band is the sum of the length of the assets falling within that band.

The national failure rate figures used were the sum of all DNO functional failures (five-year annualised average) in accordance with the Condition-based Functional Failure definition. These are shown in Appendix A.

6.1.3 Normal Expected Life

The Normal Expected Life depends on the Asset Register Category and its sub-category. It is defined as the time (in years) in an asset's life when the first significant signs of deterioration would be expected. This corresponds to a Health Score of 5.5. The value is specified in the Normal Expected Lives calibration table (Table 20, Appendix B) and is expressed in years.

6.1.4 Expected Life

Expected Life is derived from Normal Expected Life, considering two degradation factors: Location Factor (which represents the effects of the surrounding environment on the asset) and Duty Factor (which represents any additional ageing due to the way in which the asset is being used). Expected Life is calculated using EQ. 4.

$$\text{Expected Life} = \frac{\text{Normal Expected Life}}{(\text{Duty Factor} \times \text{Location Factor})}$$

EQ. 4

Location and Duty Factors are
described in more detail in Sections 6.4 - 6.6.

6.1.5 β_1 (Initial Ageing Rate)

The rate of change of the health of a distribution asset is modelled exponentially, as it is assumed that the processes involved as the asset deteriorates (e.g. corrosion, oil oxidation, insulation breakdown, etc.) are accelerated by the products of the deterioration process.

The Ageing Rate of the asset is determined from the natural logarithm of the asset's Health Score when new and the Health Score that corresponds to the Expected Life of the asset, using EQ. 5.

$$\beta_1 = \frac{\ln\left(\frac{H_{\text{expected life}}}{H_{\text{new}}}\right)}{\text{Expected Life}}$$

EQ. 5

Where:

- *H_{new} is the Health Score of a new asset, equal to 0.5*
- *$H_{Expected\ Life}$ is the Health Score of the asset when it reaches its Expected Life, equal to 5.5*
- *Expected Life is described in Section 6.1.4*

6.1.6 Initial Health Score

The Initial Health Score is obtained by defining the generic relationship between Asset Health and age using the Expected Life of the asset.

$$\text{Initial Health Score} = H_{\text{new}} \times e^{(\beta_1 \times \text{age})}$$

EQ. 6

Where:

- *H_{new} is the Health Score of a new asset, equal to 0.5*
- *Initial Health Score is capped at a value of 5.5*
- *β_1 is the initial Ageing Rate as described is Section 6.1.5*
- *age is the current age of the asset in years*

This relationship gives an initial estimate of Asset Health but does not take into account any actual health measurement or assessment that may have been carried out. This stage provides an initial age-based indication of health up to a maximum Health Score of 5.5, which needs to be modified in the next stage to take account of available data regarding the health of the asset.

6.1.7 Current Health Score

The Initial Health Score is modified according to available data using the Health Score Modifier and, where appropriate, a Reliability Modifier (see Section 6.14).

The Health Score Modifier consists of three components:-

i) Health Score Factor, which determines how the Initial Health Score is to be modified;
ii) Health Score Cap, which specifies the maximum value of Current Health Score (used in situations where a good result from a condition inspection or measurement implies that the Health Score should be no more than the specified value); and
iii) Health Score Collar, which specifies the minimum value of Current Health Score (used in situations where a poor result from a condition inspection or measurement implies that the Health Score should be at least the specified value).

The Reliability Modifier may consist of two components:-

i) A Reliability Factor; and
ii) A Reliability Collar.

The Current Health Score is calculated initially as follows:-

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

EQ. 7

The Current Health Score is then compared with Health Score Cap as follows:-

$$\begin{aligned}&\textbf{IF } \text{Current Health Score} > \text{Health Score Cap}\\&\textbf{THEN } \text{Current Health Score} = \text{Health Score Cap}\end{aligned}$$

EQ. 8

Where:

- *Current Health Score is capped at 10*

The Current Health Score is then compared with Health Score Collar as follows:-

$$\begin{aligned}&\textbf{IF } \text{Current Health Score} < \text{MAX (Health Score Collar, Reliability Collar)}\\&\textbf{THEN } \text{Current Health Score} = \text{MAX (Health Score Collar, Reliability Collar)}\end{aligned}$$

EQ. 9

Note that the order of calculation is important; the calculation must be done in the order specified to ensure that poor condition measurements override good ones; i.e. the Current Health Score must be compared with the Health Score Cap and assigned a result before comparing this result to the Health Score Collar.

Typically, the Health Score Collar is 0.5 and Health Score Cap is 10, implying no overriding of the Health Score. However, in some instances these parameters are set to other values in the Health Score Modifier calibration tables. These overriding values are shown in Table 35 to Table 202 and Table 207 in Appendix B.

6.1.8 β_2 (Forecast Ageing Rate)

In order to forecast a Future Health Score from the Current Health Score, the Ageing Rate needs to be re-calculated so that the effects of the Health Score Modifier and Reliability Modifier are taken into account. This is undertaken so that the forecast ageing reflects the Ageing Rate implied by the asset's actual condition. For assets where no ageing has been observed (i.e. the Current Health Score is 0.5) no re-calculation of the Ageing Rate is performed.

The Forecast Ageing Rate β_2 is derived from the Current Health Score and the current age of the asset using EQ. 10 when the Current Health Score > 0.5. Where the Current Health Score = 0.5, $\beta_2 = \beta_1$.

$$\beta_2 = \frac{\ln\left(\frac{\text{Current Health Score}}{H_{new}}\right)}{\text{Age}}$$

EQ. 10

Where:

- *Age is the current age of the asset (i.e. the age used in the calculation of the Initial Health Score)*
- β_2 *is capped such that:-*

$$\beta_2 \leq 2 \times \beta_1$$

EQ. 11

β_2 is capped to prevent unrealistically high rates of deterioration being applied to relatively new assets where reliability issues have been identified early on in their life.

6.1.9 Ageing Reduction Factor

The use of the exponential curve results in an escalating acceleration effect once assets reach a high Health Score. For assets that are approaching end of life, this can result in a run-away effect in the forecast future PoF, which would not reflect the deterioration that would be observed in real life.

The cause of the runaway effect is due to the imperfect match of the selected curve once the asset reaches high values of health and hence resultant PoF. To minimise the potential for overstatement of the forecast future PoF, an Ageing Reduction Factor is introduced to modify the asset's rate of deterioration. This slows down the Ageing Rate of the asset by flattening the exponential curve especially (although not exclusively) where the Health Score is greater than 5.5.

In young assets of unproven reliability, there may be a higher PoF when compared to assets of a higher age. Therefore, as an asset has reached the higher age with no identified issues, the probability is that it will continue to provide good service and hence its life expectancy is longer than the younger asset. Therefore, the old asset's PoF can be reduced in relative terms from the value calculated.

The ageing reduction technique as described above is used to reduce the forecast increase in PoF with time for assets where the Current Health Score represents any significant level of degradation. The ageing reduction factor acts by reducing the original ageing factor. This practice is in keeping with the common use by engineers of P-F interval reliability concepts [Ref. 2] which set:-

i) P as the point where a potential failure can be detected; and
ii) F as where the functional failure occurs.

In such concepts, a curve is drawn between the two points, P and F, to produce a forecast of time to failure and the reduction effect is capped so that the accelerated ageing that occurs as the asset approaches failure is correctly reflected.

In the Methodology, the Ageing Reduction Factor applied will vary, depending on the Current Health Score for the asset:-

i) for assets where the Current Health Score is greater than 5.5, the Ageing Reduction Factor is set to its maximum permissible value; and
ii) for assets where the Current Health Score is less than 2, the Ageing Reduction Factor is set to unity.

In order to prevent low Health Score assets deteriorating more quickly than high Health Score assets when forecasting, there must be no significant step change in the factor value. The Ageing Reduction Factor therefore varies linearly between unity and its maximum permissible value, for Health Scores between 2 and 5.5.

The maximum permissible value of the Ageing Reduction Factor is set to 1.5.

The Ageing Reduction Factor calibration table can be seen in Table 216 in Appendix B and is illustrated in Figure 5.

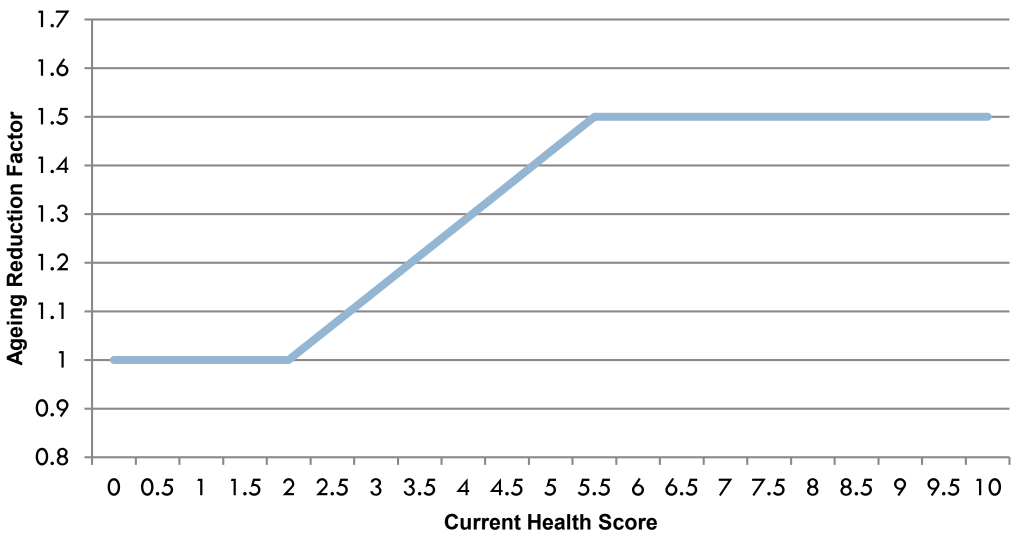

FIGURE 5: AGEING REDUCTION FACTOR

The effects of the changes to the ageing assumptions that arise from re-calculation of the Ageing Rate for forecasting future health (as described in Section 6.1.8) and the application of an Ageing Reduction Factor are shown in Figure 6. This shows three deterioration curves based on:-

i) the initial Ageing Rate, β_1;
ii) the "trued-up" Ageing Rate which would have been necessary for the asset to be in its current condition; and
iii) the application of an Ageing Reduction Factor.

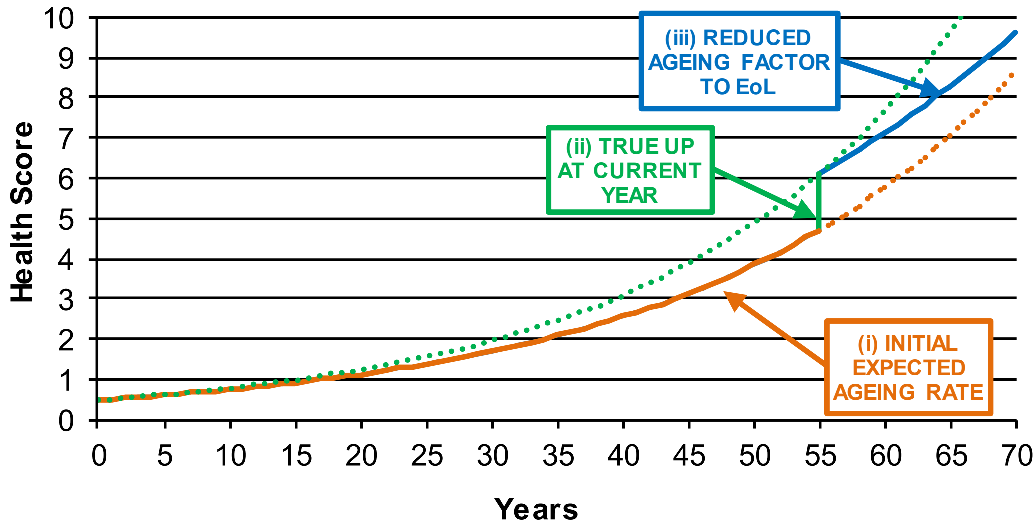

FIGURE 6: EFFECT OF AGEING REDUCTION FACTOR ON ASSET DETERIORATION

6.1.10 Future Health Score - Deterioration

The Future Health Score is calculated using the same exponential based methodology as the Initial Health Score.

$$\text{Future Health Score} = \text{Current Health Score} \times e^{((\beta_2/r) \times t)}$$

EQ. 12

Where:

- *t is the number of future years;*
- *Current Health Score is as described in Section 6.1.7;*
- *β_2 is the Forecast Ageing Rate as described in Section 6.1.8;*
- *r is the Ageing Reduction Factor as described in Section 6.1.9; and*
- *Future Health Score is capped at 15.*

6.1.11 Interventions

Interventions are activities that are undertaken to manage the risk of condition-based failure. In RIIO-ED1, DNOs have Network Asset Secondary Deliverables that relate to the improvement in risk that is delivered by Asset Replacement, as well as some Refurbishment activities. Such activities are primarily aimed at managing risk by reducing the PoF.

The effect of these activities is calculated by modifying the input data used in the Methodology. This approach shall be used for the calculation of either the Current Health Score or Future Health Score.

For Asset Replacement interventions, this is simply a recalculation of Asset Health and Criticality (and hence risk) taking account of the changes in the asset population that have resulted from the Intervention (i.e. removal of assets and the addition of new assets).

For Refurbishment interventions, the Asset Health and Criticality are recalculated using revised input data for the asset that is subject to the Refurbishment activity. This revised input data should take account of the change in input data that has resulted from the Refurbishment activity e.g. changes to the Health Score Modifier to reflect the observed or measured condition following completion of the Refurbishment.

Only certain Refurbishment activities contribute to the delivery of the Network Asset Secondary Deliverables. These are defined in Ofgem's RIIO-ED1 Regulatory Instructions and Guidance – Annex A.

Appendix C identifies these Refurbishment activities and also the input data that should be re-evaluated in order to account for the improvement in risk delivered by such activity.

6.2 PoF Calculation (HV, EHV and 132kV Transformers)

The PoF for HV Transformers, EHV Transformers (33kV & 66kV Transformers) and 132kV Transformers is derived by separate consideration of the health of two distinct subcomponents:-

i) the main transformer; and
ii) the tapchanger (EHV and 132kV Transformers only).

This recognises the degree of independence between the health of these components.

The Health Score for the overall transformer asset is derived from the combination of the Health Scores for both of these components.

Health Scores for the main transformer and tapchanger components are separately determined, using broadly the same approach as outlined in Section 6.1. This is summarised below:-

i) A separate Initial Health Score is calculated for the main transformer subcomponent and the tapchanger subcomponent, using EQ. 6, as described in Section 6.1.6. For each component different Normal Expected Lives and age information shall be used. However, the same Location Factor is applied to both the main transformer and the tapchanger but they each have a different duty factor. The Normal Expected Life of the tapchanger subcomponent and main transformer subcomponent are shown in Table 20 in Appendix B.

   To calculate the Initial Health Scores using EQ. 6:-

   - for the main transformer, the Normal Expected Life for a transformer is used and the age is taken as being the age of the main transformer component;

- for the tapchanger, the Normal Expected Life for a tapchanger is used and the age is taken as being the age of the tapchanger component.

Where the age of the tapchanger and the age of the main transformer component are not separately known, it is assumed that both components have the age that is recorded for the overall transformer asset.

ii) Separate Health Score Modifiers are calculated for both the main transformer and the tapchanger components. The calculation of these Health Score Modifiers is discussed in Section 6.8.

For both the main transformer and tapchanger components, the Health Score Modifier is derived using an Observed Condition Modifier, a Measured Condition Modifier and an Oil Test Modifier. The determination of these Modifiers is described in Sections 6.9, 6.10, 6.11.

For the main transformer subcomponent, a DGA Test Modifier and FFA Test Modifier are also used in addition to the Observed Condition Modifier, Measured Condition Modifier and Oil Test Modifier. These additional Modifiers are described in Sections 6.12 and 6.13

iii) Separate Current Health Scores are calculated for both components using the Health Score Modifier and the Initial Health Score calculated for the relevant component, e.g. the Health Score Modifier for the tapchanger component is applied to the Initial Health Score for the tapchanger component to calculate the Current Health Score for the tapchanger component.

iv) A forecast Ageing Rate, β_2, is separately calculated for each component, using the approach described in Section 6.1.8. For each component, the age used in the calculation of β_2 is the same age that was used in the calculation of the Initial Health Score.

v) The Future Health Score is calculated for each component using EQ. 12, as described in Section 6.1.10. For each component the Current Health Score and value of β_2, relating to that component, is used in the determination of the Future Health Score.

The Current Health Score of the overall transformer asset is taken as the maximum of the Current Health Score of the main transformer component and the Current Health Score of the tapchanger component.

Similarly, the Future Health Score of the overall transformer asset is taken as the maximum of the Future Health Score of the main transformer component and the Future Health Score of the tapchanger component.

The PoF for the overall transformer asset is determined by application of EQ. 3 (Section 6.1.1) to the overall Health Score (i.e. the maximum Health Score of the subcomponents).

6.3 PoF Calculation (Steel Towers)

Steel Towers are made up of individual steel members bolted together to form a lattice arrangement above ground. Tower foundations are the interlinking component between the support and the ground (soil and/or rock).

The life of a steel Tower is primarily dependent on the rate of deterioration of this steelwork both above and below ground.

New steelwork is protected from corrosion by zinc galvanising. Under normal circumstances galvanising would be expected to provide protection against the onset of corrosion, for the steelwork above ground, for a period of up to 30 years.

A paint system would normally be applied to the steelwork above ground, in order to provide a secondary form of protection against corrosion. The paintwork, itself, will deteriorate over time (typically providing protection for up to 20 years) and will require reapplication in order to maintain its protective function. The first application of a paint system to a Tower normally takes place after 30 years, once the zinc galvanising has expired.

For Towers, once corrosion has set in the intervention requirement changes considerably from low cost piecemeal steel member replacement and the application of a protective paint system, to much more expensive full Tower replacement. Therefore, with regards to the above ground steelwork, the typical strategy adopted by DNOs is to paint/refurbish before significant corrosion sets in. The typical effect of such a strategy on the Health Score of a Tower, through its life, is illustrated in Figure 7.

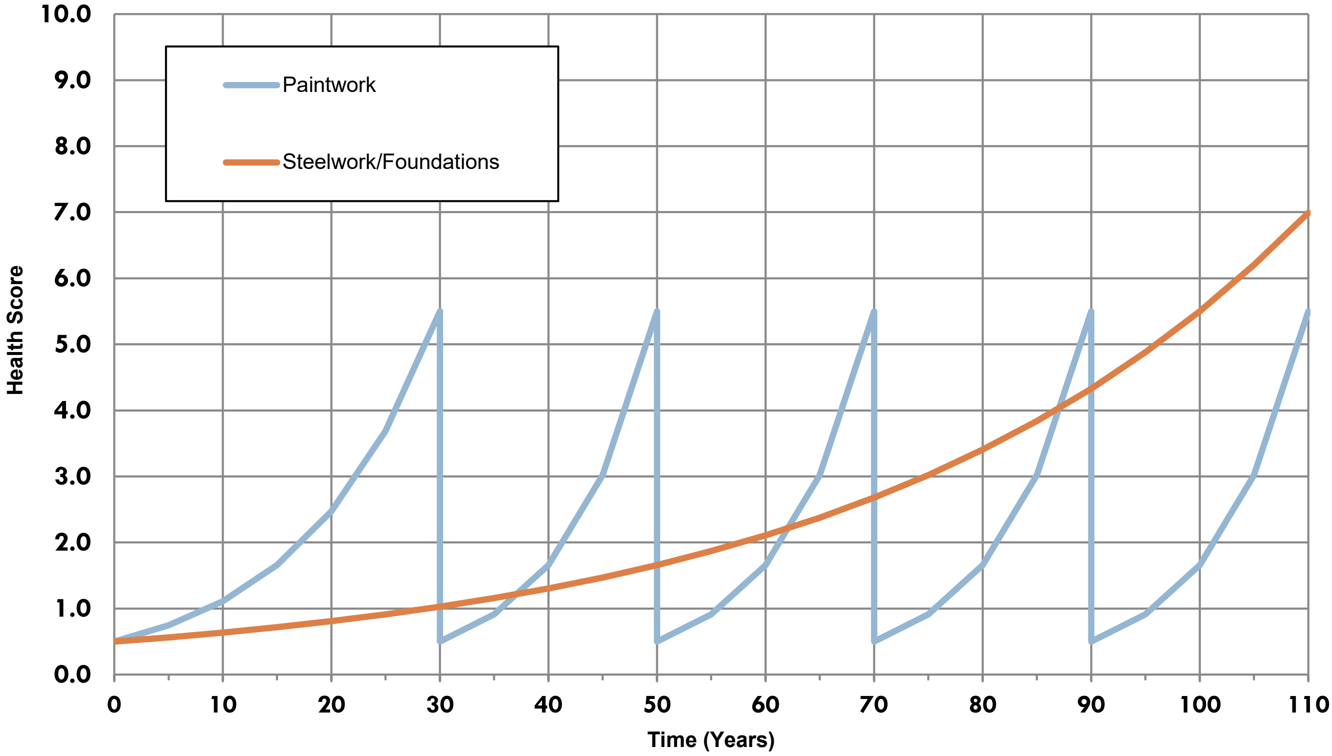

FIGURE 7: STEEL TOWER HEALTH SCORE

Therefore, within this framework the overall life cycle (Health Score) for a steel Tower is defined as a function of three discrete elements of the Tower:-

i) the paintwork;

ii) the steelwork; and
iii) the foundations.

Health Scores for each of these three components are separately determined, using broadly the same approach as outlined in Section 6.1. This is summarised below:-

i) A separate Initial Health Score is calculated for each of the three components, using EQ. 6, as described in Section 6.1.6. For each component different Normal Expected Lives and age information shall be used. However, the same Location and Duty Factors are applied to all three components. The Normal Expected Life of the paint system (rather than the Tower), foundations and steelwork are shown in Table 20 in Appendix B. To calculate the Initial Health Scores using EQ. 6:-
    - for the Tower steelwork: The Normal Expected Life of steelwork shall be used[2];
    - for the paintwork:
        - if the Tower is unpainted: The Normal Expected Life of the galvanising is used, and the age is taken as being the age of the Tower steelwork;
        - if the Tower is painted: The Normal Expected Life of paint is used, and the age is taken as time that has elapsed since the Tower was last painted;
    - for the Tower foundation: The Normal Expected Life of the Tower foundation is used, and the age is taken as being the age of the foundation.

    Where the age of the Tower steelwork and the age of the Tower foundation are not separately known, it is assumed that both the steelwork and foundation have the age that is recorded for the overall Tower.

ii) Separate Health Score Modifiers are calculated for each of the three components.

iii) Separate Current Health Scores are calculated for each of the three components using the Health Score Modifier and the Initial Health Score calculated for the relevant component, e.g. the Health Score Modifier for the paintwork component is applied to the Initial Health Score for the paintwork component to calculate the Current Health Score for the paintwork component. The Current Health Score for the paintwork component is capped at 6.4 to reflect the limited effect of paintwork, alone, on the overall health of a tower.

iv) A forecast Ageing Rate, β_2 is separately calculated for each of the three components, using the approach described in Section 6.1.8. For each component, the age used in the calculation of β_2 is the same age that was used in the calculation of the Initial Health Score.

v) A Future Health Score is calculated for each of the three components using EQ. 12, as described in Section 6.1.10. For each component the Current Health Score and value of β_2, relating to that component, shall be used in the determination of the Future

[2] The primary age of the Tower steelwork will be that of the Tower itself, accepting that some of the steelwork may have been replaced piecemeal in later years.

Health Score. The Future Health Score for the paintwork component is capped at 6.4 to reflect the limited effect of paintwork, alone, on the overall health of a tower.

The Current Health Score of the Tower is taken as the maximum of the Current Health Score of the steelwork, the Current Health Score of the paintwork and the Current Health Score of the foundations. As Paintwork condition on its own does not instigate replacement of a steel tower, a cap of 6.4 is applied to the Current Health Score of the paintwork component (as described in (iii) above). This has been done to match the impact and importance of the paintwork condition on the overall score of a Tower to reality.

Similarly, the Future Health Score of the Tower is taken as the maximum of the Future Health Score of the steelwork, the Future Health Score of the paintwork and the Future Health Score of the foundations. Again, the effect of the paintwork component upon the Future Health Score of the Tower is limited by application of a cap on the value of the Future Health Score of the paintwork (as described in (v) above).

The PoF for the overall Tower is determined by application of EQ. 3 (Section 6.1.1) to the overall Health Score (i.e. the maximum Health Score across the three subcomponents).

6.4 Location Factor (General)

6.4.1 Overview

The Expected Life of an asset is affected by the environment in which the asset is installed. For example, assets exposed to higher levels of moisture or pollution may be expected to degrade quicker than assets of the same type exposed to lower levels of moisture or pollution. The levels of exposure will depend on the location of the asset and also whether or not it is installed within an enclosure that affords protection from the weather.

This effect is recognised by the use of an asset-specific Location Factor in the determination of the Expected Life for individual assets. For all Asset Categories, except LV UGB and Cable, this Factor is influenced by:-

i) distance from coast;
ii) altitude;
iii) corrosion category; and
iv) environment (indoor / outdoor).

Where it is not known whether an asset is located indoor or outdoor, a default assumption based on the Asset Register Category shall be applied as per Table 26 in Appendix B.

Different factors are considered in the derivation of an asset-specific Location Factor for submarine cable assets. These are explained in Section 6.5.

For LV UGB assets and all non-submarine cable assets (i.e. cables installed on land), a Location Factor of 1 is assigned to all assets.

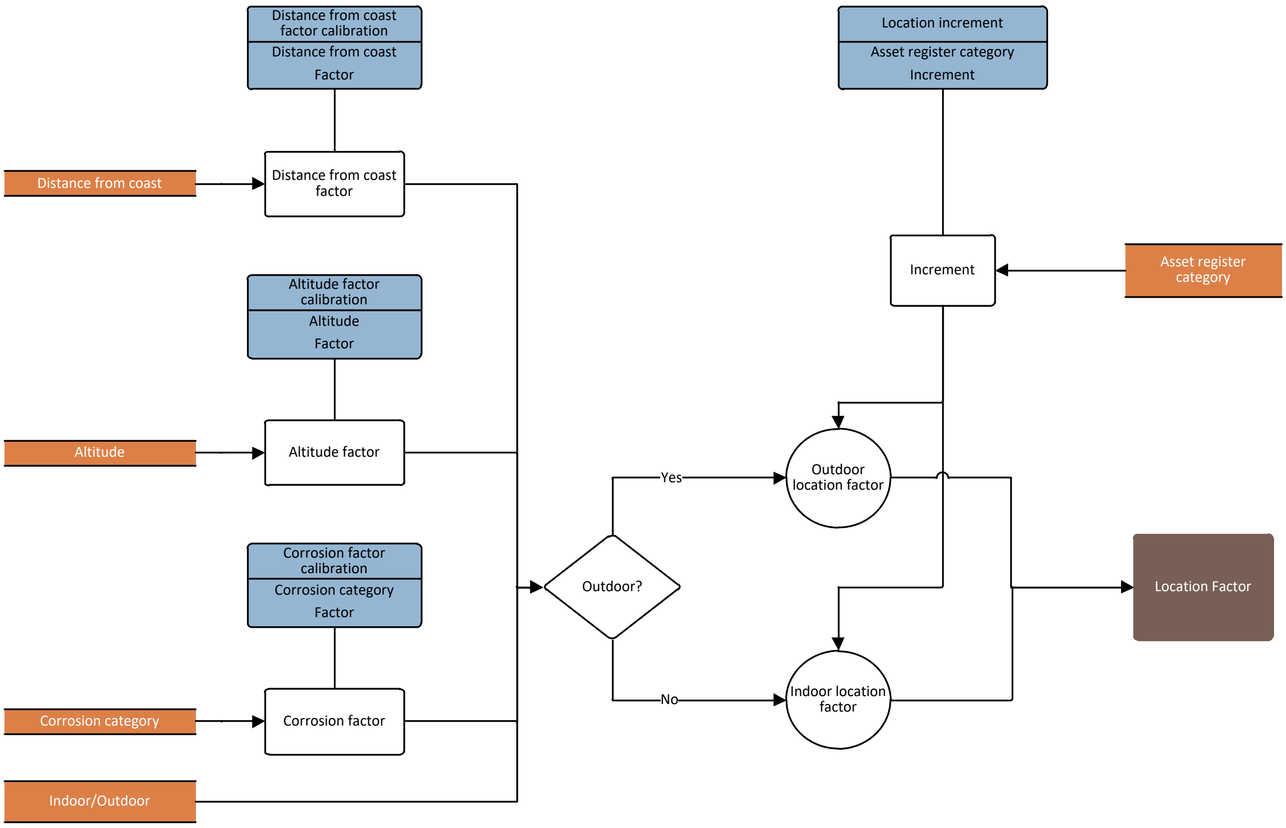

FIGURE 8: LOCATION FACTOR

6.4.2 Distance from Coast Factor

The Distance from Coast Factor is determined based on the distance of the asset (or its substation location) from the coast, measured in km. The Distance from Coast Factor is applied as shown in Table 22 in Appendix B.

6.4.3 Altitude Factor

An Altitude Factor is determined based on the altitude of the asset (or its substation location, measured in metres). The derivation of Altitude Factor is based on a look up table using bandings of altitude. The Altitude Factor is applied as shown in Table 23 in Appendix B.

6.4.4 Corrosion Factor

A Corrosion Factor is determined based on the Corrosion Category Index (1-5) for the location of the asset.[Ref.10] The Corrosion Factor is applied as shown in Table 24 in Appendix B.

6.4.5 Determining the Location Factor for assets in an outdoor environment

Where an asset is installed in an outdoor environment, the Location Factor is determined as follows:-

i) If the maximum of the Distance from Coast Factor, Altitude Factor and Corrosion Factor is greater than 1:-

$$\text{Location Factor} = \text{MAX}(\text{Distance From Coast Factor}, \text{Altitude Factor}, \text{Corrosion Factor}) + \Big(\big((\text{COUNT of factors greater than 1}) - 1\big) \times \text{INC}\Big)$$

EQ. 13

Where:

- *INC is the increment constant for the asset type (shown in Table 25)*

ii) If the maximum of the Distance from Coast Factor, Altitude Factor and Corrosion Factor is not greater than 1:-

$$\text{Location Factor} = \text{MIN}(\text{Distance From Coast Factor}, \text{Altitude Factor}, \text{Corrosion Factor})$$

EQ. 14

6.4.6 Determining the Location Factor for assets in an indoor environment

Where an asset is installed in an indoor environment, the Location Factor is determined as follows:-

i) If the maximum of the Distance from Coast Factor, Altitude Factor and Corrosion Factor is greater than 1:-

$$\text{Initial Location Factor} \\ = \text{MAX(Distance From Coast Factor, Altitude Factor, Corrosion Factor)} \\ + \big(((\text{COUNT of factors greater than 1}) - 1\big) \times \text{INC}\big)$$

EQ. 15

Where:

- *INC is the increment constant for the asset type (shown in Table 25)*

ii) If the maximum of the Distance from Coast Factor, Altitude Factor and Corrosion Factor is not greater than 1:-

$$\text{Initial Location Factor} \\ = \text{MIN(Distance From Coast Factor, Altitude Factor, Corrosion Factor)}$$

EQ. 16

iii) Steps (i) and (ii) are the same as for an asset in an outdoor environment. This additional step recognises the shielding effect of the indoor environment on the asset in question. The Location Factor is calculated from the Initial Location Factor using EQ. 17.

$$\text{Location Factor} \\ = 0.25 \times (\text{Initial Location Factor} - \text{Minimum Initial Location Factor}) \\ + \text{Minimum Initial Location Factor}$$

EQ. 17

Where:

- *Minimum Initial Location Factor is the value of Initial Location Factor that would be determined if all location factors (i.e. Distance From Coast Factor, Altitude Factor and Corrosion Factor) were at their minimum possible value for the asset type, from the calibration Table 22 to Table 24.*

6.5 Location Factor (Submarine Cables)

6.5.1 Overview

The Location Factor for Submarine Cable is made up of four factor inputs:-

i) Submarine Cable Route Topography Factor;
ii) Situation Factor;
iii) Wind/Wave Factor; and
iv) Combined Wave & Current Energy Factor.

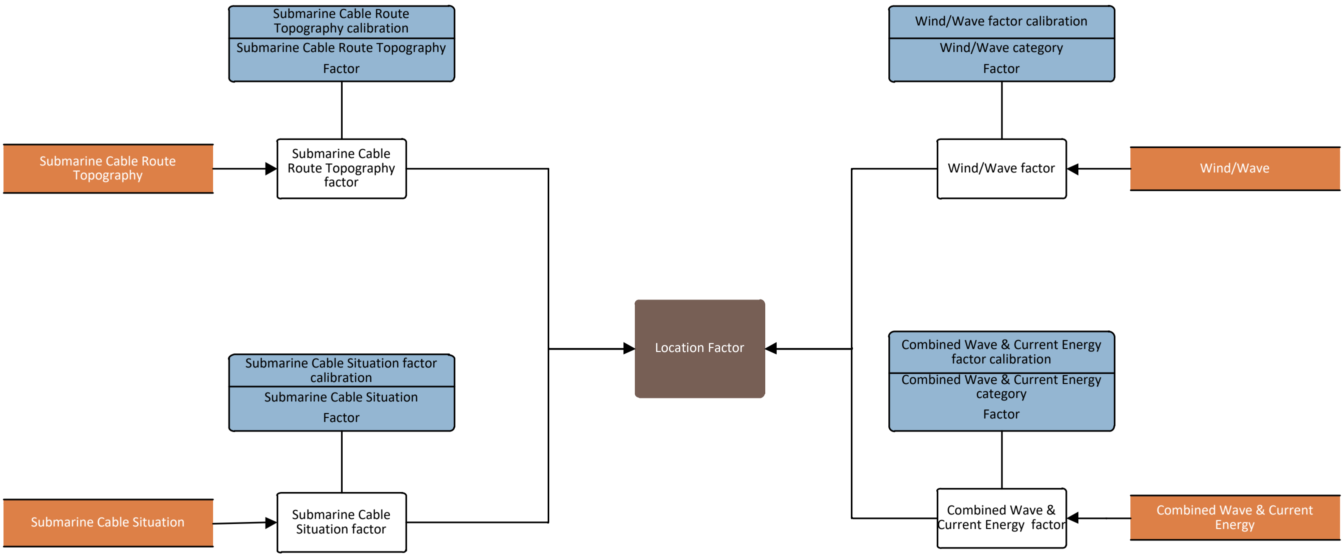

FIGURE 9: LOCATION FACTOR - SUBMARINE CABLES

6.5.2 Submarine Cable Route Topography Factor

The route topography factor considers the nature of the cable route in which the submarine cable has been laid. This considers the seabed makeup, landscape and the potential for cable to be suspended above the seabed.

The value for this factor is applied as shown in Table 27 in Appendix B.

6.5.3 Submarine Cable Situation Factor

The Submarine Cable Situation factor takes into account its installed situation: laid on bed, covered and buried.

The value for this factor is applied as shown in Table 28 in Appendix B.

6.5.4 Wind/Wave Factor

The wind and wave environment that submarine cables are subjected to has been identified as directly affecting the severity of mechanical movement (action) on the shore ends. This is captured by the wind/wave factor.

The value for this factor is applied as shown in Table 29 in Appendix B.

6.5.5 Combined Wave & Current Energy Factor

The rate at which fretting (abrasion of the cable armour) takes place is heavily dependent on the amount of energy exerted on both the cable and the seabed due to waves, tidal currents, or their combined effects. The combined wave and current energy factor takes this into account.

The value for this factor is applied as shown in Table 30 in Appendix B.

6.5.6 Determining the Location Factor for Submarine Cables

If the maximum of the Submarine Cable Route Topography Factor, Situation Factor, Wind/Wave Factor, Combined Wave & Current Energy Factor is greater than 1:-

$$\text{Location Factor} = \text{MAX}(\text{Submarine Cable Route Topography Factor}, \text{Situation Factor}, \text{Wind/Wave Factor}, \text{Combined Wave \& Current Energy Factor}) + \Big(\big((\text{COUNT of factors greater than } 1) - 1\big) \times \text{INC}\Big)$$

EQ. 18

Where:

- *INC is the increment constant for the asset type (Table 25, Appendix B)*

If the maximum of the Submarine Cable Route Topography Factor, Situation Factor, Wind/Wave Factor, Combined Wave & Current Energy Factor is not greater than 1:-

$$\text{Location Factor} = \text{MIN}(\text{Submarine Cable Route Topography Factor}, \text{Situation Factor}, \text{Wind/Wave Factor}, \text{Combined Wave \& Current Energy Factor})$$

EQ. 19

6.6 Duty Factor

The Expected Life of an asset varies depending on the duty to which it is subjected.

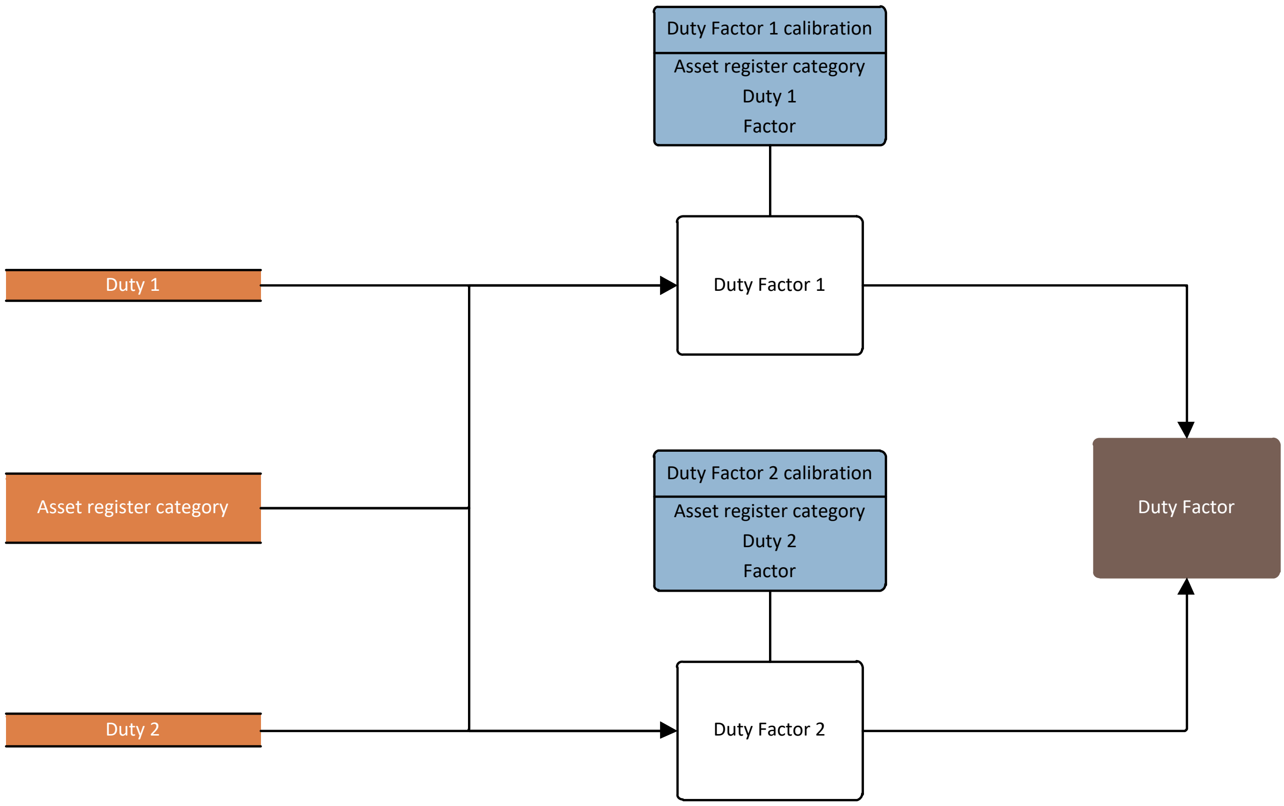

FIGURE 10: DUTY FACTOR

For electrical assets, the duty factor is a function of loading, number of operations, design voltage and operating voltage. Table 8 shows how these factors are to be applied to the different Asset Categories:

TABLE 8: DUTY FACTOR METHODOLOGY

Asset Category	Duty Factor 1 (DF1)	Duty Factor 2 (DF2)
Cables	% Utilisation	Operating Voltage ÷ Design Voltage
Poles	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
LV UGB	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Switchgear - LV	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Switchgear - HV Distribution	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Switchgear - HV Primary	Number of Operations	N/A
Switchgear - EHV & 132kV		
Steel Tower	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Conductor	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
Fittings	No asset-specific Duty Factor 1 (i.e. DF1 = 1)	N/A
HV Transformer (GM)	% Utilisation	N/A
Transformers - EHV & 132kV	Transformer: % Utilisation	N/A
	Tapchanger: Average Number of Daily Tapping Operations	N/A

Where there is only a single Duty Factor, then:-

$$\text{Duty Factor} = \text{DF1}$$

EQ. 20

Where two Factors are combined to create the Duty Factor, then:-

$$\text{Duty Factor} = 0.5 \times \text{DF1} + 0.5 \times \text{DF2}$$

EQ. 21

The Duty Factor lookup tables which are applied to the respective Asset Categories are shown in Table 31 to Table 34.

6.7 Health Score Modifier

6.7.1 Overview

Asset-specific Health Score Modifiers are calculated for each individual asset. The Health Score Modifier is determined from observed condition and measurement results. The Health Score Modifier is used to inform the Current Health Score, such that it reflects the observed health of the asset.

For all Health Index Asset Categories, except for EHV Towers, 132kV Towers, HV Transformers, EHV Transformers and 132kV Transformers, a single Health Score Modifier is calculated for each asset. The calculation of Health Score for assets in the EHV Towers, 132kV Towers, HV Transformers, EHV Transformers and 132kV Transformers Asset Categories requires separate evaluation of the Health Score for several subcomponents. Consequently, for these Asset Categories, separate Health Score Modifiers are evaluated for each subcomponent. In such cases, the appropriate Health Score Modifier is applied to determine the Current Health Score for each subcomponent of the asset.

The Health Score Modifier consists of three elements:-

i) a Health Score Factor, which is a multiplication factor, derived from Condition Modifiers, that is applied to the Initial Health Score;
ii) a Health Score Cap, which is a maximum limit that is applied to the product of the Initial Health Score and the Health Score Factor; and
iii) a Health Score Collar, which is a minimum limit that is applied to the product of the Initial Health Score and the Health Score Factor.

Where a cap or a collar is applied an explanation for the application is provided in the associated table values in the appropriate appendices.

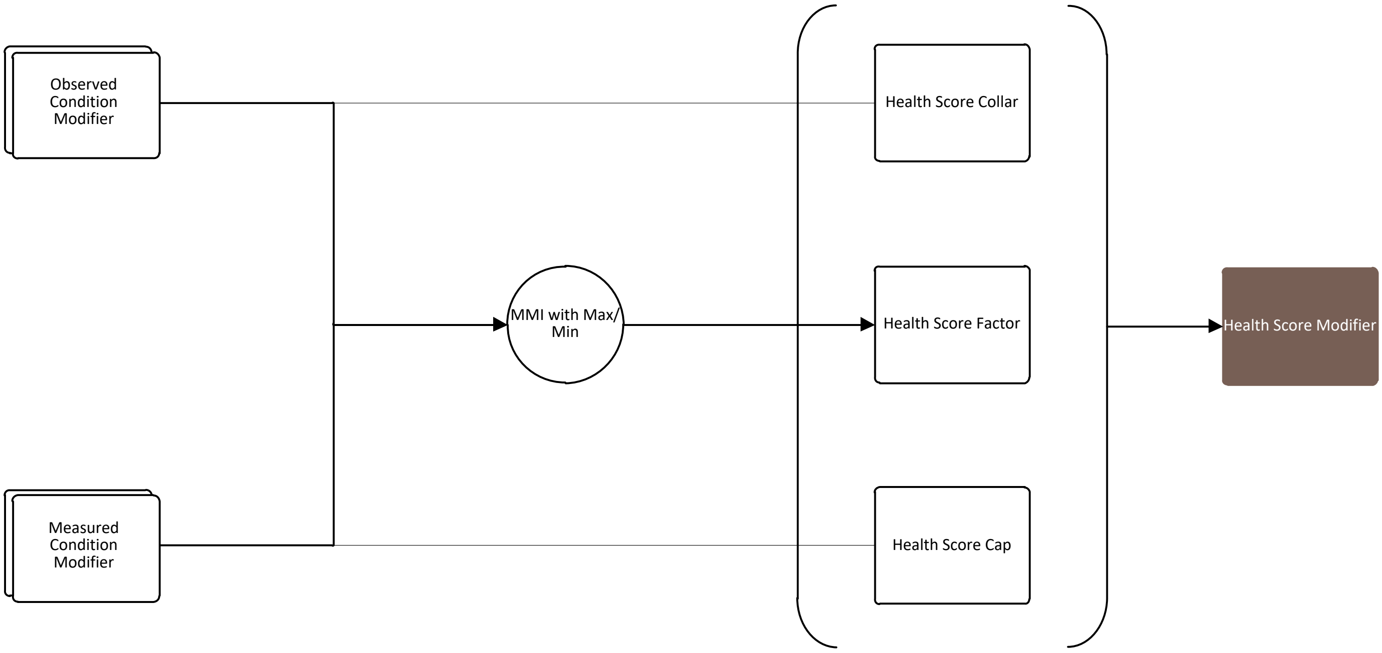

FIGURE 11: HEALTH SCORE MODIFIER

For assets, other than those in the HV, EHV and 132kV Transformer Health Index Asset Categories, the Health Score Modifier is determined by combining:-

i) an Observed Condition Modifier, based on Observed Condition Inputs (such as condition assessment observations); and
ii) a Measured Condition Modifier, based on Measured Condition Inputs.

The derivation of the Observed Condition Modifier and Measured Condition Modifier are described in Sections 6.9 and 6.10. Like the Health Score Modifier, each of these Condition Modifiers is comprised of three elements, i.e.: -

i) a Condition Factor, which is a value associated with an observation or measurement, used to derive the Health Score Factor;
ii) a Condition Cap, which is a maximum limit that is used to derive the Health Score Cap; and
iii) a Condition Collar, which is a minimum limit that is used to derive the Health Score Collar.

The derivation of the Health Score Modifier for the HV, EHV and 132kV Transformer Asset Categories is described separately in Section 6.8*.*

In determining the Health Score Modifier, only the Condition Modifiers (and associated Condition Inputs) specified within the Methodology are applied. In recognition of different inspection and assessment approaches between DNOs:-

i) There is no requirement for data to be collected to apply all the Condition Inputs specified within the Methodology. Where DNOs do not have data available to determine a specific Condition Input, the default values for that Condition Input (as specified in the calibration table for that Condition Input) are applied.
ii) The calibration tables for each Condition Input (Appendices B.5 and B.6) are defined in terms of the outcomes or conclusions drawn from the relevant condition assessments or tests and are common to all DNOs. Where required, DNOs shall map data from their own systems against the relevant criteria shown on the calibration tables. This enables common Condition Inputs to be determined for all DNOs without

specifying the exact format of data that is collected in each individual DNOs inspection and assessment regimes.

iii) It will be permissible for DNOs to combine multiple measurements or observations from their own data set (or adjust for elapsed time since the condition data was collected) in their mapping to an individual Condition Input.

DNOs shall be required to record all mappings of their data to the Methodology's Condition Inputs within their own Network Asset Indices Methodology.

6.7.2 Combining Factors Using a Maximum and Multiple Increment (MMI) Technique

The Condition Factors, which form part of the Condition Modifiers, are combined together to derive the Health Score Factor using a technique that is referred to as "maximum and multiple increment". The calculation of the Health Score Factor is described in Section 6.7.3.

Each specific Condition Factor is derived from multiple Condition Input Factors, which come from associated lookup tables that map the observed or measured condition to a Condition Input Factor.

The combination of Condition Inputs to create the Observed Condition Modifier and the Measured Condition Modifier is described in Sections 6.9 and 6.10. This also uses an MMI approach.

By using the MMI approach throughout, this ensures that the Health Score Factor is primarily driven by the strongest observed or measured Condition Input Factor, supplemented to a lesser and controlled degree by any additional Condition Input Factors (depending on their strength).

This approach enables a single methodology to be applied to all asset groups, with the variation between asset groups captured through calibration factors.

Whilst multiple Factors may be considered in the derivation of a single combined Factor using the MMI technique, there will be instances where not all of the multiple Factors affect the resulting Factor. This is because:-

i) where all of the multiple Factors are less than, or equal to 1, the resulting combined single Factor is determined from only the lowest and second lowest of the multiple Factors; and

ii) where any of the multiple Factors are greater than 1, the resulting combined single Factor will be determined from consideration of the highest of the multiple Factors and a given number of the next highest Factors. The total number of Factors considered in each case will be no greater than the Max. No. of Combined Factors, which is a calibration parameter that is specified for each instance that the MMI technique is applied. The Max. No. of Combined Factors describes the total number of Factors that may be considered in the derivation of the combined single Factor, which is a count of Factors that includes the maximum Factor and any additional Factors that may be used to supplement it.

The combination of multiple Factors into a single Factor using the MMI technique is described below:-

If any of the Factors is greater than 1:

- Var_1 = Maximum of Factors
- Var_2 = Excluding Var_1,
    - For remaining Factors where (Factor - 1) > 0
    - Sum (Factor - 1) for the highest n-1 of these; where *n* = *Max. No. of Combined Factors*
- Var_3 = Var_2 / Factor Divider 1
- Combined Factor = Var_1 + Var_3

- Else
    - Var_1 = Minimum of Factors
    - Var_2 = Second Lowest of Factors
    - Var_3 = (Var_2 - 1) / Factor Divider 2
    - Combined Factor = Var_1 + Var_3

Where:

- *Max. No. of Combined Factors specifies how many Factors are able to simultaneously affect the Combined Factor.*
- *Factor Divider 1 and Factor Divider 2 are constants that specify the degree to which additional "good" or "bad" Factors are able further drive the Combined Factor.*

A case statement description of this algorithm is demonstrated below.

Case 1: one or more Factors > 1

- Factors = 1.2, 1.0, 1.1, 1.02, 0.9, Max. No of Combined Factors = 4, Factor Divider 1 and Factor Divider 2 = 2
- Var 1 = maximum of Factors = Max(1.2, 1.0, 1.1, 1.02, 0.9) = 1.2
- Var 2 = sum remaining Factors where Factor - 1 > 0 = (1.1-1) + (1.02 - 1) = 0.12
- Var 3 = Var 2 / Factor Divider 1 = 0.12 / 2 = 0.06
- Combined Factor = Var 1 + Var 3 = 1.2 + 0.06 = 1.26

Case 2: all Factors ≤ 1

- Factors = 1, 1, 0.8, 1, 0.9, Max. No of Combined Factors = 4, Factor Divider 1 and Factor Divider 2 = 2
- Var 1 = minimum of Factors = Min(1, 1, 0.8, 0.9) = 0.8
- Var 2 = Second minimum of Factors = 2^{nd}Min(1, 1, 0.8, 0.9) = 0.9
- Var 3 = (Var 2 - 1) / Factor Divider 2 = (0.9 - 1) / 2 = -0.05
- Combined Factor = Var 3 + Var 1 = 0.8 + -0.05 = 0.75

6.7.3 Health Score Factor Calculation

The Health Score Factor is a multiplier that is applied to the Initial Health Score.

The Observed and Measured Condition Factors are combined to derive the Health Score Factor using the MMI technique described in Section 6.7.2.

For assets, other than those in the HV, EHV Transformer and 132kV Transformer Health Index Asset Categories, Factor Divider 1 and Factor Divider 2 have a value of 1.5 and the Max. No. of Combined Factors is 2. This means that the description of the combination method can be simplified to:-

i) The Health Score Factor for an individual asset is determined by evaluating:-
   - the maximum of the Observed Condition Factor and the Measured Condition Factor for the asset; and
   - the minimum of the Observed Condition Factor and the Measured Condition Factor for the asset.

ii) The calculation used to determine the Health Score Factor is dependent on the magnitudes of the maximum and minimum Condition Factors. The Health Score Factor is calculated as shown in Table 9.

TABLE 9: HEALTH SCORE FACTOR

a = Maximum of (Observed Condition Factor, Measured Condition Factor)	**b =** Minimum of (Observed Condition Factor, Measured Condition Factor)	**Health Score Factor**
>1	>1	= a + ((b-1)/1.5)
>1	≤1	= a
≤1	≤1	= b + ((a-1)/1.5)

The derivation of the Health Score Factor for the HV, EHV Transformer and 132kV Transformer Asset Categories is described separately in Section 6.8.

6.7.4 Health Score Cap

For assets, other than those in the HV, EHV and 132kV Transformer Health Index Asset Categories, the Health Score Cap is the minimum of:-

i) The Observed Condition Cap associated with the Observed Condition Modifier; or
ii) The Measured Condition Cap associated with the Measured Condition Modifier.

The derivation of the Condition Caps associated with the Observed and Measured Condition Modifiers is described in Sections 6.9.3 and 6.10.3 respectively.

The derivation of the Health Score Cap for the HV, EHV and 132kV Transformer Asset Categories is described in Section 6.8.

6.7.5 Health Score Collar

For assets, other than those in the HV, EHV and 132kV Transformer Health Index Asset Categories, the Health Score Collar is the maximum of:-

i) The Observed Condition Collar associated with the Observed Condition Modifier; or
ii) The Measured Condition Collar associated with the Measured Condition Modifier.

The derivation of the Condition Collars associated with the Observed and Measured Condition Modifiers is described in Sections 6.9.4 and 6.10.4 respectively.

The derivation of the Health Score Collar for the HV, EHV and 132kV Transformer Asset Categories is described in Section 6.8.

In all cases, the Health Score Collar shall be limited to a value of no greater than 10.

6.8 Health Score Modifier for HV, EHV and 132kV Transformers

6.8.1 Main Transformer

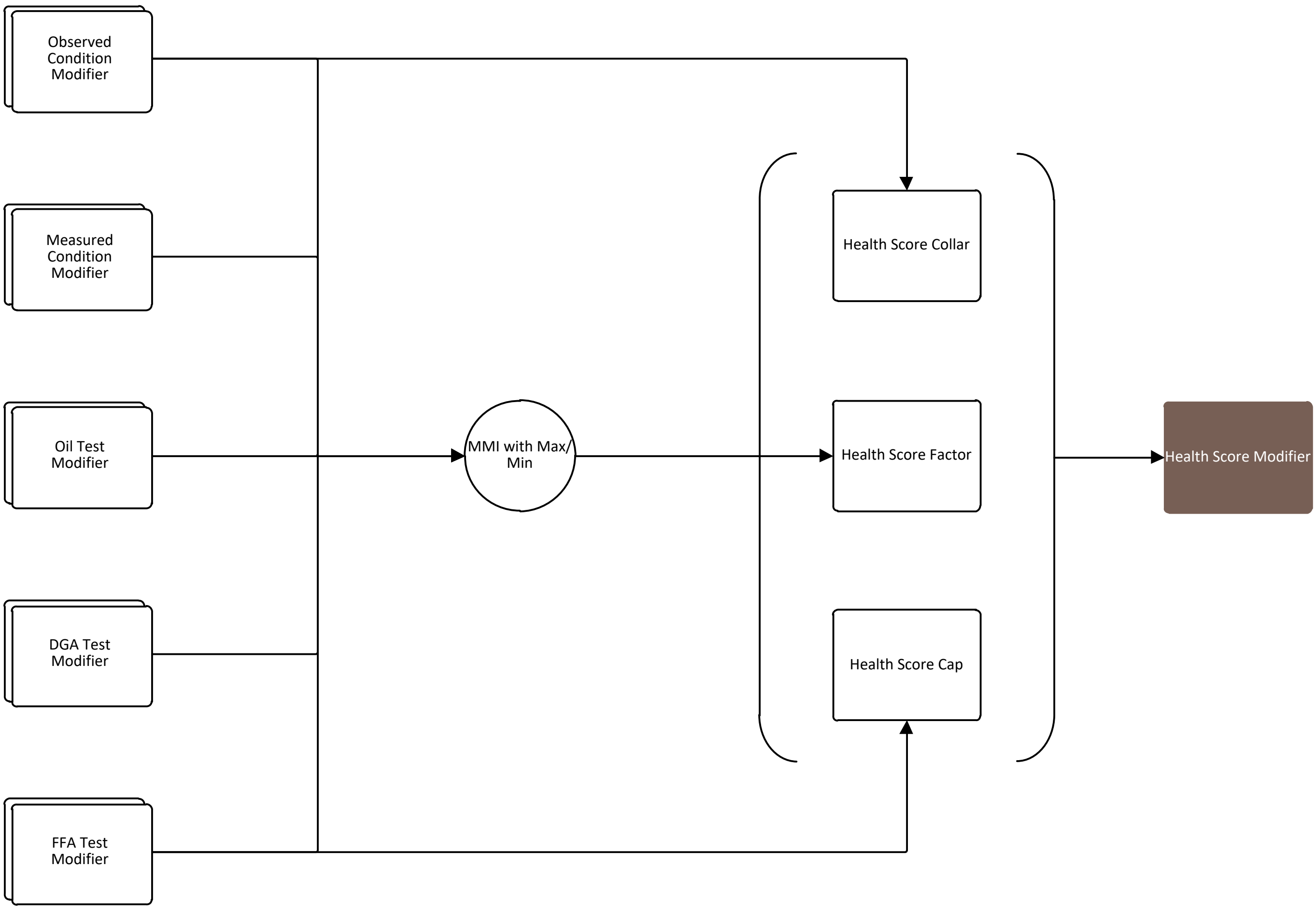

FIGURE 12: HEALTH SCORE MODIFIER - MAIN TRANSFORMER

The Health Score Modifier for HV, EHV and 132kV Transformers is derived in exactly the same way as for a generic Health Score Modifier, apart from the following differences:

i) There are three additional Condition Modifiers to the model: the Oil Test Modifier, the DGA Test Modifier and the FFA Test Modifier.

ii) The parameters used to combine the Factors associated with these Condition Modifiers in order to derive the Health Score Factor are as shown in Table 10.

TABLE 10: HEALTH SCORE FACTOR FOR TRANSFORMERS

Parameters for Combination Using MMI Technique		
Factor Divider 1	Factor Divider 2	Max. No. of Condition Factors
1.5	1.5	4

These additional inputs enable the Health Score of the Main Transformer component to be determined with greater accuracy.

6.8.2 Tapchanger for EHV and 132kV Transformers only

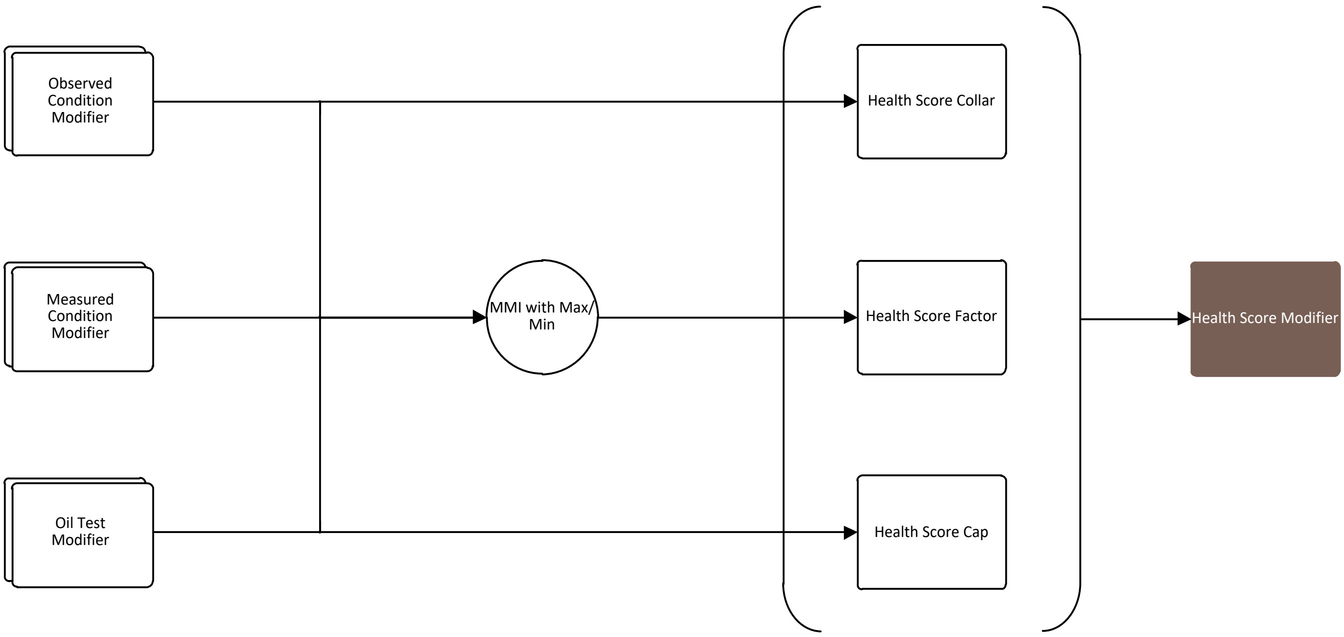

FIGURE 13: HEALTH SCORE MODIFIER - TAPCHANGER

The Health Score Modifier for a Transformer Tapchanger (where the Health Score needs to be separately determined) is derived in the same way as for a generic Health Score Modifier, apart from the following differences:

i) There is an additional Condition Modifier to the model: the Oil Test Modifier.
ii) The parameters used to combine the Factors associated with these Condition Modifiers in order to derive the Health Score Factor are as shown in Table 11.

TABLE 11: HEALTH SCORE FACTOR FOR TAPCHANGERS

Parameters for Combination Using MMI Technique		
Factor Divider 1	**Factor Divider 2**	**Max. No. of Condition Factors**
1.5	1.5	2

This additional input enables the Health Score of the Tapchanger to be determined with greater accuracy.

6.9 Observed Condition Modifier

6.9.1 Overview

The Observed Condition Modifier is used in the determination of the Health Score Modifier.

An asset-specific Observed Condition Modifier is determined for each individual asset. For all Health Index Asset Categories, except for EHV Towers, 132kV Towers, HV Transformers, EHV Transformers and 132kV Transformers, a single Observed Condition Modifier is calculated for each asset.

The calculation of Health Score for assets in the EHV Towers, 132kV Towers, HV Transformers, EHV Transformers and 132kV Transformers Health Index Asset Categories requires separate evaluation of the Health Score for subcomponents of these assets. Consequently, for these Asset Categories, separate Observed Condition Modifiers are evaluated for each subcomponent associated with each asset.

This Condition Modifier is based on observed condition.

The Observed Condition Modifier consists of three components:-

i) an Observed Condition Factor, which used in the derivation of the Health Score Factor;
ii) an Observed Condition Cap, which is a maximum limit of Health Score that is used in the derivation of the Health Score Cap; and
iii) an Observed Condition Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

Multiple Observed Condition Inputs are used to derive the Observed Condition Modifier. Each Observed Condition Input consists of three elements:-

i) a Condition Input Factor;
ii) a Condition Input Cap; and
iii) a Condition Input Collar.

The Condition Input Factors are used to derive the Observed Condition Factor using the MMI technique described in Section 6.7.2. Each Condition Input Cap is used in the derivation of the Observed Condition Cap and each Condition Input Collar is used in the derivation of the Observed Condition Collar.

The calibration tables relating to each of the Observed Condition Inputs are shown in Appendix B.5. The values assigned to each Condition Input, for an asset, are determined by looking up the relevant Condition Input values that correspond to the DNO's data for that asset.

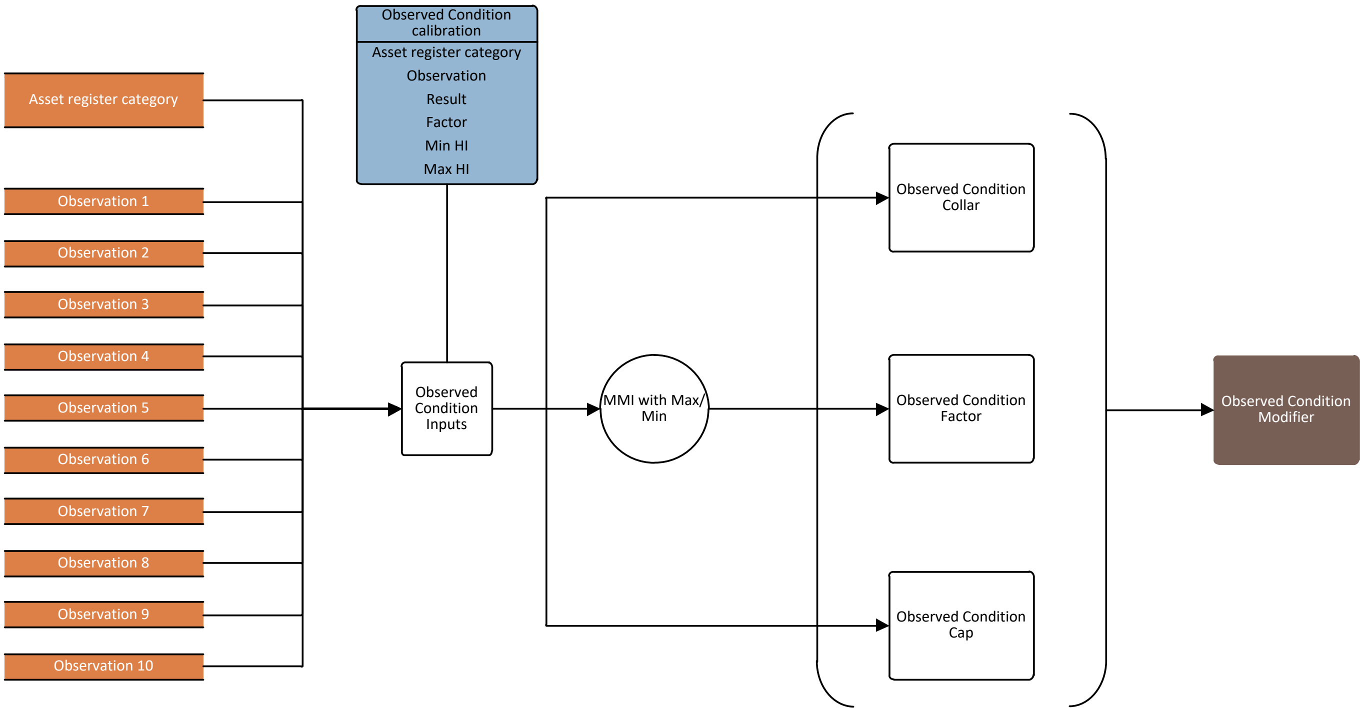

FIGURE 14: OBSERVED CONDITION MODIFIER

Table 12 shows the Observed Condition Inputs that are included in the determination of the Observed Condition Modifier for each Asset Category.

TABLE 12: OBSERVED CONDITION INPUTS

Asset Category	Subcomponent	Observed Condition Input
LV UGB	N/A	1. Steel Cover and Pit condition 2. Water/Moisture 3. Bell Condition 4. Insulation Condition 5. Signs of heating 6. Phase Barriers
LV Circuit Breaker	N/A	1. Switchgear external condition
LV Board (WM)	N/A	1. Switchgear external condition 2. Compound Leaks 3. Switchgear internal condition and operation 4. Insulation 5. Signs of Heating 6. Phase Barriers
LV Pillar	N/A	1. Switchgear external condition 2 . Compound Leaks 3. Switchgear internal condition and operation 4. Insulation 5. Signs of Heating 6. Phase Barriers
HV Switchgear (GM) - Primary	N/A	1. Switchgear external condition 2. Cable boxes condition 3. Oil leaks/ Gas pressure 4. Thermographic Assessment 5. Switchgear internal condition and operation 6. Indoor Environment

Asset Category	Subcomponent	Observed Condition Input
HV Switchgear (GM) - Distribution	N/A	1. Switchgear external condition 2. Cable boxes condition 3. Oil leaks/ Gas pressure 4. Thermographic Assessment 5. Switchgear internal condition and operation 6. Indoor Environment
EHV Switchgear (GM)	N/A	1. Switchgear external condition 2. Cable boxes condition 3. Oil leaks/ Gas pressure 4. Thermographic Assessment 5. Switchgear internal condition and operation 6. Indoor Environment 7. Support Structures
132kV Switchgear (GM)	N/A	1. Switchgear external condition 2. Cable boxes condition 3. Oil leaks/ Gas pressure 4. Thermographic Assessment 5. Switchgear internal condition and operation 6. Indoor Environment 7. Support Structures 8. Air systems
HV Transformer (GM)	N/A	1. Transformer external condition 2. Cable boxes condition
EHV Transformer (GM)	Main Transformer	1. Main tank condition 2. Coolers/Radiator condition 3. Bushings condition 4. Kiosk condition 5. Cable boxes condition
	Tapchanger	1. Tapchanger external condition 2. Internal Condition 3. Drive Mechanism Condition 4. Condition of Selector & Diverter Contacts 5. Condition of Selector & Diverter Braids
132kV Transformer (GM)	Main Transformer	1. Main tank condition 2. Coolers/Radiator condition 3. Bushings condition 4. Kiosk condition 5. Cable boxes condition
	Tapchanger	1. Tapchanger external condition 2. Internal Condition 3. Drive Mechanism Condition 4. Condition of Selector & Diverter Contacts 5. Condition of Selector & Diverter Braids
EHV Cable (Non Pressurised)	N/A	None
EHV Cable (Oil)	N/A	1. Presence of Crystalline Lead
EHV Cable (Gas)	N/A	1. Presence of Crystalline Lead
132kV Cable (Non Pressurised)	N/A	None
132kV Cable (Oil)	N/A	1. Presence of Crystalline Lead
132kV Cable (Gas)	N/A	1. Presence of Crystalline Lead
Submarine Cable	N/A	1. External Condition of Armour

Asset Category	Subcomponent	Observed Condition Input
LV Poles	N/A	1. Visual Pole Condition 2. Pole Top Rot 3. Pole Leaning 4. Bird / Animal Damage
HV Poles	N/A	1. Visual Pole Condition 2. Pole Top Rot 3. Pole Leaning 4. Bird / Animal Damage
EHV Poles	N/A	1. Visual Pole Condition 2. Pole Top Rot 3. Pole Leaning 4. Bird / Animal Damage
EHV Towers	Tower Steelwork	1. Tower Legs 2. Bracings 3. Crossarms 4. Peak
	Tower Paintwork	1. Paintwork Condition
	Foundations	1. Foundation Condition
132kV Towers	Tower Steelwork	1. Tower Legs 2. Bracings 3. Crossarms 4. Peak
	Tower Paintwork	1. Paintwork Condition
	Foundations	1. Foundation Condition
EHV Fittings	N/A	1. Tower fittings 2. Conductor fittings 3. Insulators - Electrical 4. Insulators - Mechanical
132kV Fittings	N/A	1. Tower fittings 2. Conductor fittings 3. Insulators - Electrical 4. Insulators - Mechanical
EHV Tower Line Conductor	N/A	1. Visual Condition 2. Midspan joints
132kV Tower Line Conductor	N/A	1. Visual Condition 2. Midspan joints

6.9.2 Observed Condition Factor

The Observed Condition Factor is used in the derivation of the Health Score Factor.

For each asset, multiple Observed Condition Input Factors are combined to create the Observed Condition Factor. These Observed Condition Input Factors are combined using the MMI technique that is described in Section 6.7.2.

Table 13 shows the parameters that are used when combining the Observed Condition Input Factors using the MMI technique.

TABLE 13: OBSERVED CONDITION MODIFIER - MMI CALCULATION PARAMETERS

Asset Category	Subcomponent	Parameters for Combination Using MMI Technique		
		Factor Divider 1	Factor Divider 2	Max. No. of Combined Factors
LV UGB	N/A	1.5	1.5	3
LV Circuit Breaker	N/A	1.5	1.5	1
LV Board (WM)	N/A	1.5	1.5	3
LV Pillar	N/A	1.5	1.5	3
HV Switchgear (GM) - Primary	N/A	1.5	1.5	3
HV Switchgear (GM) - Distribution	N/A	1.5	1.5	3
EHV Switchgear (GM)	N/A	1.5	1.5	3
132kV Switchgear (GM)	N/A	1.5	1.5	3
HV Transformer (GM)	N/A	1.5	1.5	2
EHV Transformer (GM)	Main Transformer	1.5	1.5	3
	Tapchanger	1.5	1.5	3
132kV Transformer (GM)	Main Transformer	1.5	1.5	3
	Tapchanger	1.5	1.5	3
EHV Cable (Non Pressurised)	N/A	N/A	N/A	N/A
EHV Cable (Oil)	N/A	1.5	1.5	1
EHV Cable (Gas)	N/A	1.5	1.5	1
132kV Cable (Non Pressurised)	N/A	N/A	N/A	N/A
132kV Cable (Oil)	N/A	1.5	1.5	1
132kV Cable (Gas)	N/A	1.5	1.5	1
Submarine Cable	N/A	1.5	1.5	1
LV Poles	N/A	1.5	1.5	2
HV Poles	N/A	1.5	1.5	2
EHV Poles	N/A	1.5	1.5	2
EHV Towers	Tower Steelwork	1.5	1.5	3
	Tower Paintwork	1.5	1.5	1
	Foundations	1.5	1.5	1
132kV Towers	Tower Steelwork	1.5	1.5	3
	Tower Paintwork	1.5	1.5	1
	Foundations	1.5	1.5	1
EHV Fittings	N/A	1.5	1.5	3
132kV Fittings	N/A	1.5	1.5	3
EHV Tower Line Conductor	N/A	1.5	1.5	1
132kV Tower Line Conductor	N/A	1.5	1.5	1

6.9.3 Observed Condition Cap

The Observed Condition Cap for an asset is the minimum value of Condition Input Cap associated with each of the Observed Condition Inputs relating to that asset (as shown in the calibration tables for Observed Condition Inputs in Appendix B).

6.9.4 Observed Condition Collar

The Observed Condition Collar for an asset is the maximum value of Condition Input Collar associated with each of the Observed Condition Inputs relating to that asset (as shown in the calibration tables for Observed Condition Inputs in Appendix B).

6.9.5 Observed Condition Modifier for EHV Cable (Non Pressurised) and 132kV Cable (Non Pressurised)Assets

As shown in Table 12, EHV Cable (Non Pressurised) and 132kV Cable (Non Pressurised) are the only asset categories where no Observed Condition Inputs are applicable. For these asset categories:-

i) the Observed Condition Factor is set to 1;
ii) the Observed Condition Cap is 10; and
iii) the Observed Condition Collar is 0.5.

6.10 Measured Condition Modifier

6.10.1 Overview

The Measured Condition Modifier is used in the determination of the Health Score Modifier.

An asset-specific Measured Condition Modifier is determined for each individual asset.

For all Health Index Asset Categories, with the exception of EHV Towers, 132kV Towers, EHV Transformers and 132kV Transformers, a single Measured Condition Modifier is calculated for each asset.

The calculation of Health Score for assets in the EHV Towers, 132kV Towers, EHV Transformers and 132kV Transformers Health Index Asset Categories requires separate evaluation of the Health Score for subcomponents of these assets. Consequently, for these Asset Categories, separate Measured Condition Modifiers are evaluated for each subcomponent associated with each asset.

This Condition Modifier is based on measured condition.

The Measured Condition Modifier consists of three components:-

i) a Measured Condition Factor, which is used in the derivation of the Health Score Factor;
ii) a Measured Condition Cap, which is a maximum limit of Health Score that is used in the derivation of the Health Score Cap; and
iii) a Measured Condition Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

Multiple Measured Condition Inputs are used to derive the Measured Condition Modifier. Each Measured Condition Input consists of three elements:-

i) a Condition Input Factor;
ii) a Condition Input Cap; and
iii) a Condition Input Collar.

The Condition Input Factors are used to derive the Measured Condition Factor using the MMI technique described in Section 6.7.2. Each Condition Input Cap is used in the derivation of the Measured Condition Cap and each Condition Input Collar is used in the derivation of the Measured Condition Collar.

The calibration tables relating to each of the Measured Condition Inputs are shown in Appendix B.6. The values assigned to each Condition Input for a particular asset are determined by looking up the relevant Condition Input values that correspond to the DNO's data for that asset.

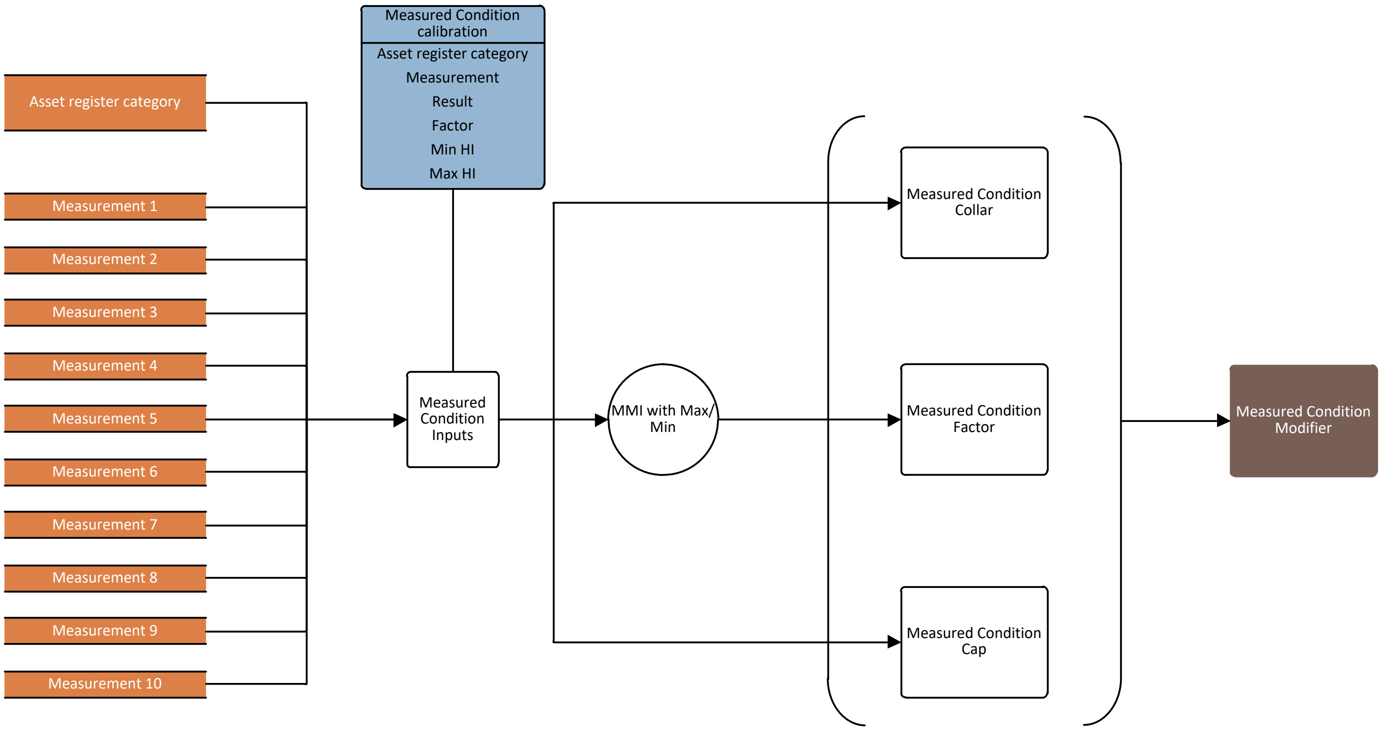

FIGURE 15: MEASURED CONDITION MODIFIER

Table 14 shows the Measured Condition Inputs that are included in the determination of the Measured Condition Modifier for each Asset Category.

TABLE 14: MEASURED CONDITION INPUTS

Asset Category	Subcomponent	Measured Condition Input
LV UGB	N/A	1. Operational Adequacy
LV Circuit Breaker	N/A	1. Operational Adequacy
LV Board (WM)	N/A	1. Operational Adequacy
LV Pillar	N/A	1. Operational Adequacy
HV Switchgear (GM) - Primary	N/A	1. Partial Discharge 2. Ductor Test 3. IR Test 4. Oil Tests 5. Temperature Readings 6. Trip Test
HV Switchgear (GM) - Distribution	N/A	1. Partial Discharge 2. Ductor Test 3. Oil Tests 4. Temperature Readings 5. Trip Test

Asset Category	Subcomponent	Measured Condition Input
EHV Switchgear (GM)	N/A	1. Partial Discharge 2. Ductor Test 3. IR Test 4. Oil Tests/ Gas Tests 5. Temperature Readings 6. Trip Test
132kV Switchgear (GM)	N/A	1. Partial Discharge 2. Ductor Test 3. IR Test 4. Oil Tests/ Gas Tests 5. Temperature Readings 6. Trip Test
HV Transformer (GM)	N/A	1. Partial Discharge 2. Temperature Readings
EHV Transformer (GM)	Main Transformer	1. Partial Discharge 2. Temperature Readings
	Tapchanger	1. Tapchanger Partial Discharge
132kV Transformer (GM)	Main Transformer	1. Partial Discharge 2. Temperature Readings
	Tapchanger	1. Tapchanger Partial Discharge
EHV Cable (Non Pressurised)	N/A	1. Sheath Test 2. Partial Discharge 3. Fault history
EHV Cable (Oil)	N/A	1. Leakage
EHV Cable (Gas)	N/A	1. Leakage
132kV Cable (Non Pressurised)	N/A	1. Sheath Test 2. Partial Discharge 3. Fault history
132kV Cable (Oil)	N/A	1. Leakage
132kV Cable (Gas)	N/A	1. Leakage
Submarine Cable	N/A	1. Sheath Test 2. Partial Discharge 3. Fault history
LV Poles	N/A	1. Pole decay / deterioration
HV Poles	N/A	1. Pole decay / deterioration
EHV Poles	N/A	1. Pole decay / deterioration
EHV Towers	Tower Steelwork	None
	Tower Paintwork	None
	Foundations	None
132kV Towers	Tower Steelwork	None
	Tower Paintwork	None
	Foundations	None
EHV Fittings	N/A	1. Thermal Imaging 2. Ductor Tests
132kV Fittings	N/A	1. Thermal Imaging 2. Ductor Tests
EHV Tower Line Conductor	N/A	1. Conductor Sampling 2. Corrosion Monitoring Survey

Asset Category	Subcomponent	Measured Condition Input
132kV Tower Line Conductor	N/A	1. Conductor Sampling 2. Corrosion Monitoring Survey

6.10.2 Measured Condition Factor

The Measured Condition Factor is used in the derivation of the Health Score Factor.

For each asset, multiple Measured Condition Input Factors are combined to create the Measured Condition Factor. These Measured Condition Input Factors are combined using the MMI technique that is described in Section 6.7.2.

Table 15 shows the parameters that are used when combining the Measured Condition Factors using the MMI technique.

TABLE 15: MEASURED CONDITION MODIFIER - MMI CALCULATION PARAMETERS

Asset Category	Subcomponent	Parameters for Combination Using MMI Technique		
		Factor Divider 1	Factor Divider 2	Max. No. of Combined Factors
LV UGB	N/A	1.5	1.5	1
LV Circuit Breaker	N/A	1.5	1.5	1
LV Board (WM)	N/A	1.5	1.5	1
LV Pillar	N/A	1.5	1.5	1
HV Switchgear (GM) - Primary	N/A	1.5	1.5	3
HV Switchgear (GM) - Distribution	N/A	1.5	1.5	3
EHV Switchgear (GM)	N/A	1.5	1.5	3
132kV Switchgear (GM)	N/A	1.5	1.5	3
HV Transformer (GM)	N/A	1.5	1.5	2
EHV Transformer (GM)	Main Transformer	1.5	1.5	2
	Tapchanger	1.5	1.5	1
132kV Transformer (GM)	Main Transformer	1.5	1.5	2
	Tapchanger	1.5	1.5	1
EHV Cable (Non Pressurised)	N/A	1.5	1.5	2
EHV Cable (Oil)	N/A	1.5	1.5	1
EHV Cable (Gas)	N/A	1.5	1.5	1
132kV Cable (Non Pressurised)	N/A	1.5	1.5	2
132kV Cable (Oil)	N/A	1.5	1.5	1
132kV Cable (Gas)	N/A	1.5	1.5	1
Submarine Cable	N/A	1.5	1.5	2
LV Poles	N/A	1.5	1.5	1
HV Poles	N/A	1.5	1.5	1
EHV Poles	N/A	1.5	1.5	1
EHV Towers	Tower Steelwork	N/A	N/A	N/A
	Tower Paintwork	N/A	N/A	N/A
	Foundations	N/A	N/A	N/A
132kV Towers	Tower Steelwork	N/A	N/A	N/A
	Tower Paintwork	N/A	N/A	N/A
	Foundations	N/A	N/A	N/A
EHV Fittings	N/A	1.5	1.5	1
132kV Fittings	N/A	1.5	1.5	1
EHV Tower Line Conductor	N/A	1.5	1.5	1
132kV Tower Line Conductor	N/A	1.5	1.5	1

6.10.3 Measured Condition Cap

The Measured Condition Cap for an asset is the minimum value of Condition Input Cap associated with each of the Measured Condition Inputs relating to that asset (as shown in the calibration tables for Measured Condition Inputs in Appendix B).

6.10.4 Measured Condition Collar

The Measured Condition Collar for an asset is the maximum value of Condition Input Collar associated with each of the Measured Condition Inputs relating to that asset (as shown in the calibration tables for Measured Condition Inputs in Appendix B).

6.10.5 Measured Condition Modifier for Steel Towers (Structure Only)

There are no Measured Condition Inputs for Steel Towers (Steelwork, Paint or Foundation components). For these assets:-

i) the Measured Condition Factor is set to 1;
ii) the Measured Condition Cap is 10; and
iii) the Measured Condition Collar is 0.5.

6.11 Oil Test Modifier

The Oil Test Modifier is derived from the oil condition information (moisture content, acidity and breakdown strength) [Ref. 3 & 4]. It provides additional information to determine the Health Score when oil condition test data is available. This test data can be used to identify defects or degradation within the asset and is therefore used to increase the Health Score when necessary.

The Oil Test Modifier consists of three components:-

i) An Oil Test Factor, which used in the derivation of the Health Score Factor;
ii) an Oil Test Cap, which is a maximum limit of Health Score that used in the derivation of the Health Score Cap; and
iii) an Oil Test Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

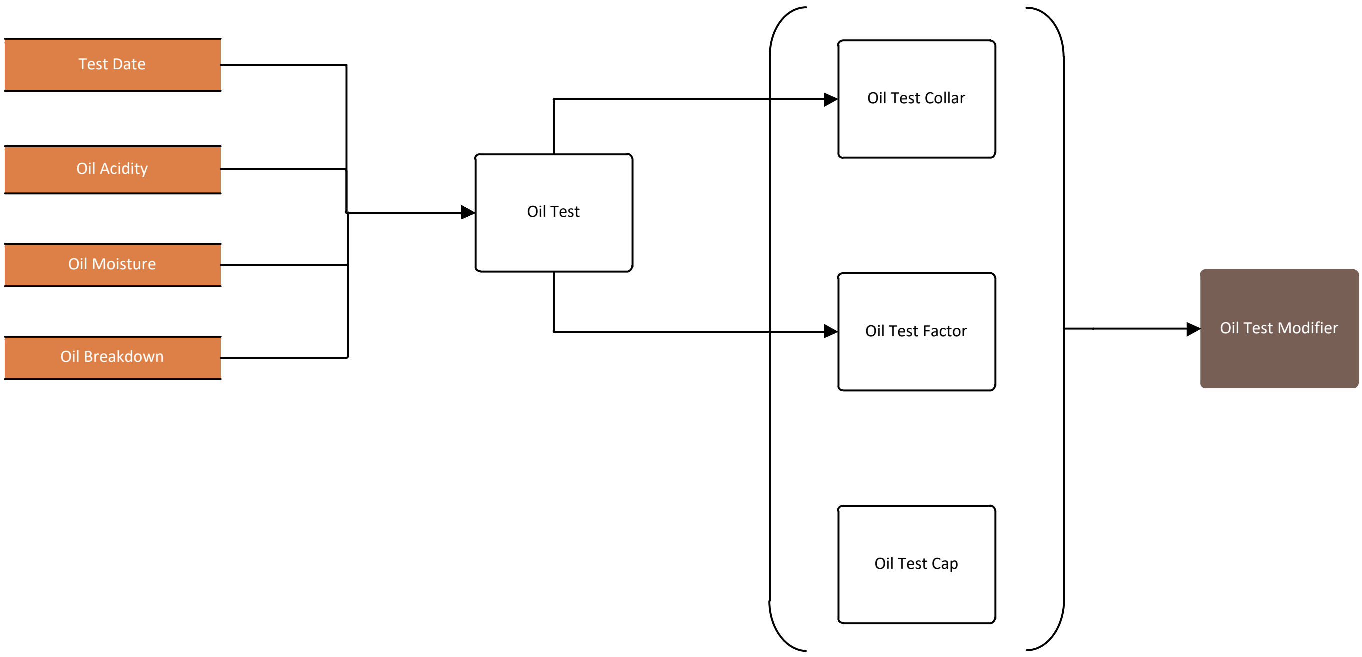

FIGURE 16: OIL TEST MODIFIER

The process for converting the results into a score and subsequently into an Oil Test Factor, an Oil Test Cap and an Oil Test Collar is as follows:

i) The moisture, acidity and breakdown strength results are standardised by converting them into scores using the Condition State calibration tables; respectively Table 203, Table 204 and Table 205 in Appendix B.

ii) The scores for the three condition points (moisture, breakdown strength and acidity) are then multiplied by the values relative to the importance of the measured condition point and summed to create an Oil Condition Score as shown in EQ. 22.

$$\text{Oil Condition Score} = 80 \times \text{Moisture Score} + 125 \times \text{Acidity Score} + 80 \times \text{Breakdown Strength Score}$$

EQ. 22

iii) The Oil Condition Factor and Oil Test Collar value are then derived using the lookup values shown in Table 206 and Table 207 in Appendix B.

iv) The Oil Test Cap is always set to 10: because oil can be renewed, oil tests are unable to determine the absence of degradation in an asset - only its presence. Therefore, the Oil Test Cap cannot be set to less than 10, regardless of the Oil Test result.

6.12 DGA Test Modifier

The DGA Test Modifier is derived from the dissolved gas content in the oil [Ref. 5]. It provides additional information to determine the Health Score when DGA test data is available. This test data can be used to detect abnormal electrical or thermal activity within the asset and is therefore used to increase the Health Score when necessary.

The DGA Test Modifier consists of three components:-

i) a DGA Test Factor, which is used in the derivation of the Health Score Factor;

ii) a DGA Test Cap, which is a maximum limit of Health Score that is used in the derivation of the Health Score Cap; and

iii) a DGA Test Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

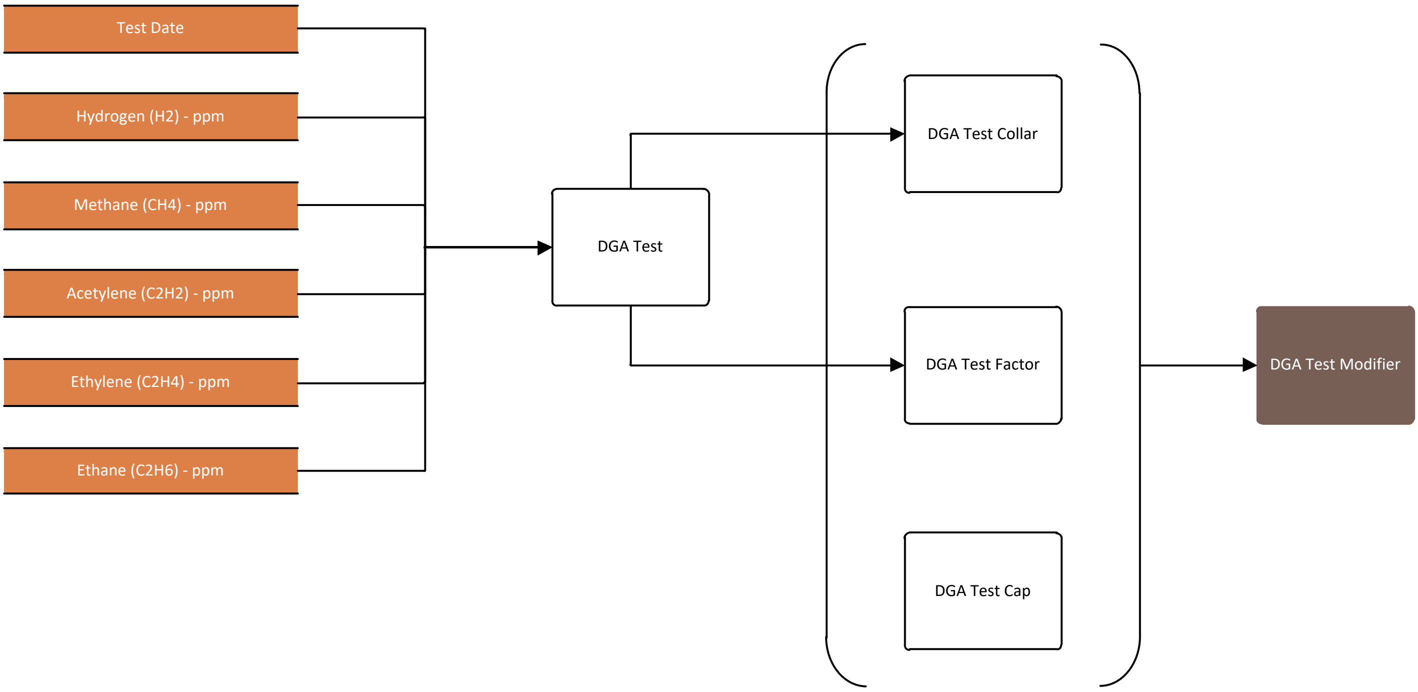

FIGURE 17: DGA TEST MODIFIER

The diagnostic process described here was developed by EA Technology in conjunction with a number of GB Distribution Network Operators within Module 4 of the Strategic Technology Programme [Ref. 4]. Of nine gases measured during DGA (namely oxygen, nitrogen, carbon monoxide, carbon dioxide, hydrogen, methane, ethylene, ethane and acetylene) only the latter five were recognised as providing an indication of transformer condition.

Therefore, only the levels of the following gases are used to derive the DGA Test Modifier:-

i) Hydrogen;
ii) Methane;
iii) Ethylene;
iv) Ethane; and
v) Acetylene.

The gas levels used to produce this modifier are calibrated to give a DGA Test Collar of 7 or greater if there is indication of a potential end of life fault. The result of this analysis is used to determine the DGA Test Collar and the DGA Test Factor. The DGA Test Cap is always set to 10.

The results for each of the five gases are standardised by converting them into scores using condition state calibration tables; these are shown in Table 208 - Table 212 in Appendix B.

The condition state scores for the five gases (hydrogen, methane, ethane, ethylene and acetylene) are then multiplied by values relative to the importance of the quantity of each gas measured and summed to create a DGA Score as shown in EQ. 23.

$$\text{DGA Score} = 50 \times \text{Hydrogen Score} + 30 \times \text{Methane Score} + 30 \times \text{Ethylene Score} + 30 \times \text{Ethane Score} + 120 \times \text{Acetylene Score}$$

EQ. 23

In order to create a DGA Test Collar that can be considered in the Health Score Factor calculation, in the range of 0.5 to 10, the DGA Score is divided by a DGA divider value; this is set at 220 as shown in EQ. 24.

$$\text{DGA Test Collar} = \text{DGA Score} \div 220$$

EQ. 24

This value is chosen to give a Health Score of 7 at the point where DGA levels are indicative of severe degradation. In the absence of DGA records a default DGA Test Collar of 0.5 is used.

For EHV and 132kV Transformers, the DGA Test Factor is then created by considering the trend with historical results (over a defined period) for the same asset. The percentage change is derived as shown in EQ. 25.

$$\%\ \text{Change} = \frac{\text{DGA Score}_{\text{latest}} - \text{DGA Score}_{\text{previous}}}{\text{DGA Score}_{\text{previous}}} \times 100\%$$

EQ. 25

This is used to categorise the trend into one of five categories or bands (negative, neutral, small, significant or large), as depicted in calibration Table 213 in Appendix B.

The category or band is then used to assign the DGA Test Factor, using the calibration Table 214 in Appendix B.

For HV Transformers, the DGA Test Factor is always set to 1 as DGA tests are not routinely undertaken, which prevents comparison with previous results.

The DGA Test Cap is always set to 10: because oil can be renewed, DGA tests are unable to determine the absence of degradation in an asset - only its presence. Therefore, the DGA Test Cap cannot be set to less than 10, regardless of the DGA test result.

6.13 FFA Test Modifier

The FFA Test Modifier is derived from the level of furfuraldehyde (FFA) in oil. It provides additional information to determine the Health Score when FFA test data is available. This test data can be used to detect degradation of cellulose paper, and hence residual mechanical strength of insulation within the asset. It is used to increase the Health Score when necessary.

The FFA Test Modifier consists of three components:-

i) an FFA Test Factor, which is used in the derivation of the Health Score Factor;
ii) an FFA Test Cap, which is a maximum limit of Health Score that is used in the derivation of the Health Score Cap; and
iii) an FFA Test Collar, which is a minimum limit of Health Score that is used in the derivation of the Health Score Collar.

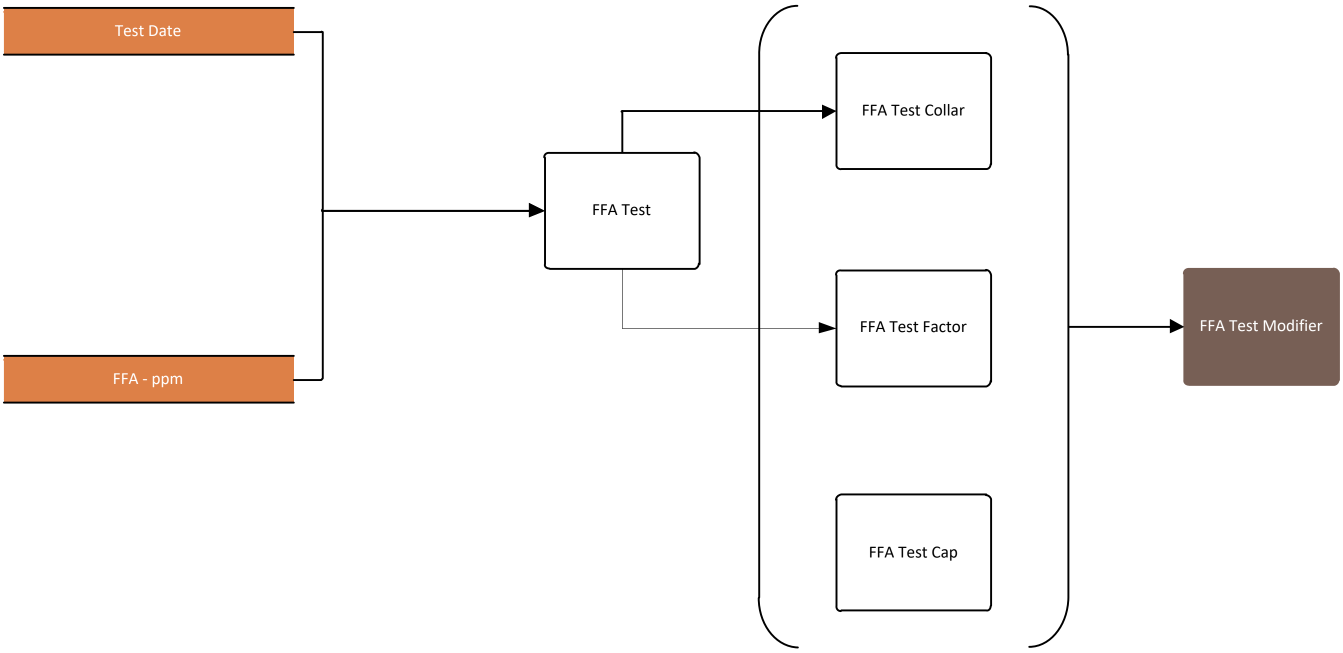

FIGURE 18: FFA TEST MODIFIER

The FFA Test Collar is derived from the furfuraldehyde (FFA) value.

Furfuraldehyde is one of a family of compounds (furans) produced when cellulose (paper) degrades. As the paper ages, the cellulose chains progressively break, reducing the mechanical strength. The average length of the cellulose chains is defined by the degree of polymerisation (DP) which is a measure of the number of Carbon-Carbon bonds or the length of chains making up the paper fibres. In a new transformer, the DP value is approximately 1000. When this is reduced to approximately 250, the paper has very little remaining strength and is at risk of failure during operation.

There is an approximate relationship between the value of furfuraldehyde in the oil and the DP of the paper, which has been established experimentally. A value of 5ppm of FFA is indicative of paper with a DP of approximately 250. For this reason, the FFA Test Collar is calibrated to give a value of 7 for a FFA value of 5; this empirical relationship has been mathematically described as shown in EQ. 26.

$$\text{FFA Test Collar} = 2.33 \times S^{0.68}$$

Where: **EQ. 26**

- *S is the FFA value in ppm.*

The FFA Test Factor is determined from the FFA value using the calibration Table 215 in Appendix B. The default value for the FFA Test Factor is 1.

The FFA Test Cap is always set to 10.

6.14 Reliability Modifier

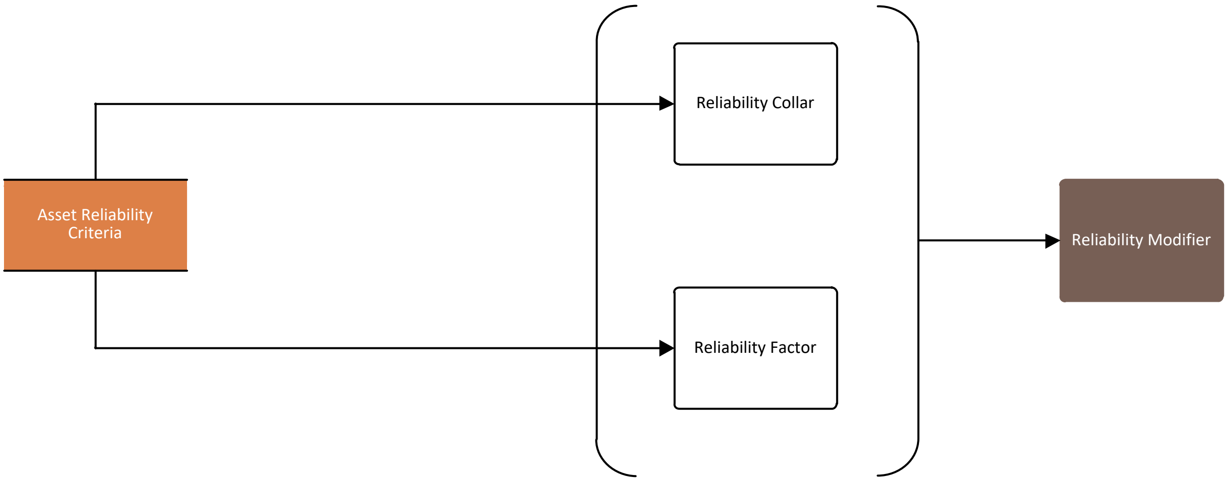

FIGURE 19: RELIABILITY MODIFIER

An additional Reliability Modifier may be applied (at individual DNO discretion) to the Current Health Score of those assets that the individual DNO believes have a materially different PoF than would be expected for a typical asset within the same Asset Category with the same Health Score, because of generic issues that affect health/reliability associated with:-

i) the make and type of the asset; and
ii) the construction of the asset (e.g. material used, or treatment applied).

Typically, these issues would have been identified from manufacturer notifications, failure investigations, forensic analysis or because of inspections from assets of the same make or type. This recognises that there are wider sources of knowledge about the condition and performance of individual assets.

Where a DNO applies a Reliability Modifier to an asset, this shall be documented within their own Network Asset Indices Methodology.

The Reliability Modifier may comprise of two separate components:-

i) a multiplication factor applied in the calculation of the Current Health Score (the Reliability Factor); and
ii) a Health Score Collar applied as a minimum limit to the Current Health Score (the Reliability Collar).

The Reliability Factor shall be applied as a multiplier to the Current Health Score that is derived from the initial age-based Health Score and the Health Score Modifier.

The Reliability Collar shall be applied as a minimum limit to the Health Score that is derived from the initial age-based Health Score, the Health Score Modifier and the Reliability Factor (where applied).

The Reliability Factor shall have a value between 0.6 and 1.5 with a default value of 1. The default value for the Reliability Collar shall be 0.5. Each DNO has discretion over whether the Reliability Modifier applied to individual asset types comprises:-

i) only a Reliability Factor;
ii) only a Reliability Collar; or
iii) both.

When applying Reliability Modifiers, individual DNOs may use any appropriate data they have relating to the asset or assets. This will include their own defect databases as well as information gathered as part of the national notification process for:-

i) National Equipment Defect Reports (NEDeRs);
ii) Dangerous Incident Notifications (DINs); or
iii) Suspension of Operational Practice notices (SOPs).

7. CONSEQUENCES OF FAILURE

7.1 Overview

The second key dimension of the Methodology is a consideration of the consequences of asset failure. This is used in combination with an assessment of the probability of asset failure to derive a single value for network risk.

The Methodology breaks the effects of failure down into four Consequence Categories:-

i) Financial;
ii) Safety;
iii) Environmental; and
iv) Network Performance.

Each of these is quantified in terms which allow for the monetisation within each Consequence Category. The four values are then simply added to produce an overall CoF value. All quoted values are in £ (at 2020/21 prices).

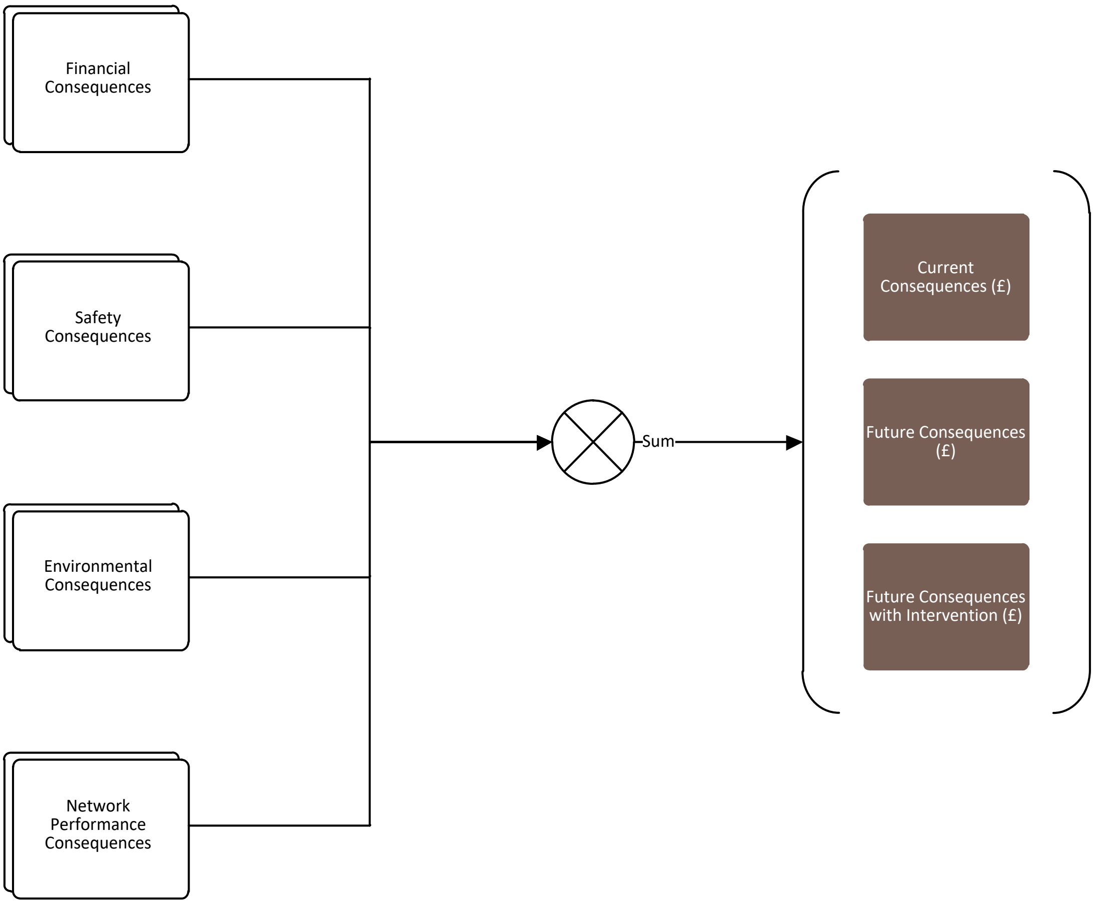

FIGURE 20: CONSEQUENCES OF FAILURE

These are the only Consequence Categories considered within the Methodology.

CoF is generally assumed to remain static over time, unless affected by investment or third-party actions, hence current consequence and forecast future consequence values will generally be the same.

The calculation of CoF is based on the same failure modes as PoF, i.e. Incipient Failure, Degraded Failure and Catastrophic Failure.

The Methodology is based on the production of a Reference Cost of Failure for each asset type which represents the 'typical' effects of a failure based on DNO experience. Asset-specific costs are based on the application of specific modifying factors to these reference costs to reflect the costs associated with a condition-based failure of the asset in question. The reference costs and factors used within the Methodology are common for all DNOs. This process is shown in Figure 21.

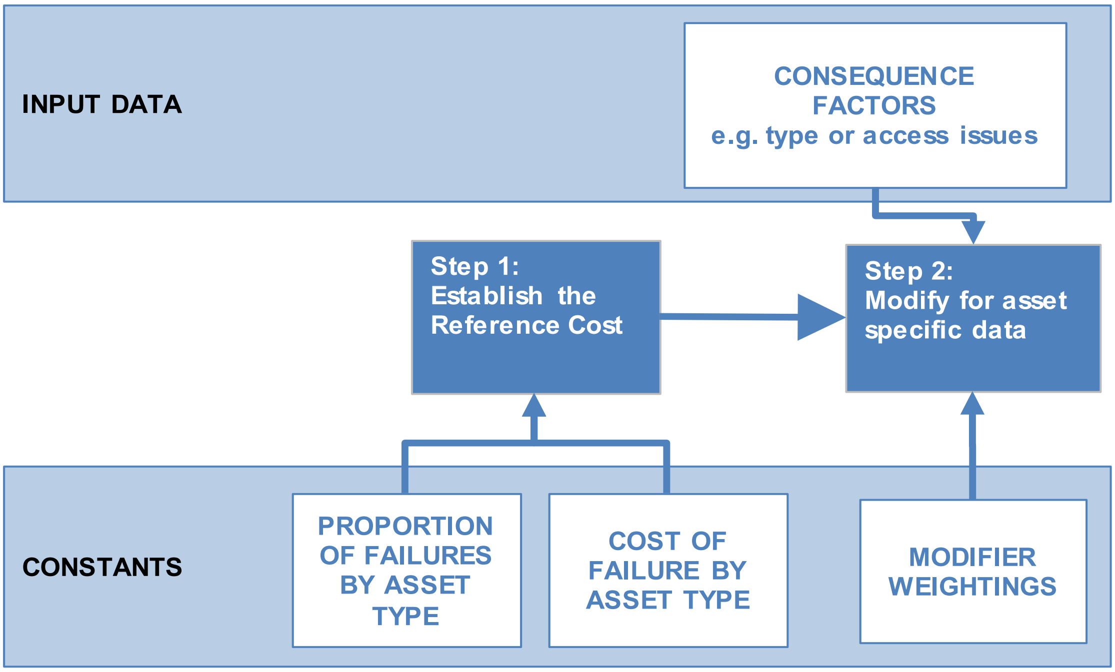

FIGURE 21: COF METHODOLOGY

The interdependence of assets in terms of Network Performance is considered at EHV and 132kV (typically N-1 assets) by including a factor for coincident failure in deriving the Reference Network Performance Cost of Failure. This is done by considering the Probability of a Coincident Outage (see Table 235). Other assets are assumed to be independent of one another, reflecting the radial nature of distribution networks. However, the impact of the failure of one asset on the propensity of another asset to fail is implicitly included in the observable failure rate and hence the PoF parameters (e.g. K-Value in Table 21).

7.2 Reference Costs of Failure

The following sections set out the process to produce the Reference Costs of Failure and modifying factors for each of the four Consequence Categories within the Methodology. These costs are shown in Table 16.

TABLE 16: REFERENCE COSTS OF FAILURE

Asset Register Category	Financial*	Safety*	Environmental*	Network Performance*	Total*
LV Poles	£1,337	£601	£90	£542	£2,570
6.6/11kV Poles	£1,913	£200	£90	£1,930	£4,133
20kV Poles	£2,295	£200	£90	£1,930	£4,515
33kV Pole	£2,466	£200	£90	£92	£2,847
66kV Pole	£3,718	£200	£90	£183	£4,191
33kV Tower	£6,749	£377	£186	£580	£7,893
66kV Tower	£12,647	£377	£186	£1,663	£14,873
132kV Tower	£14,623	£377	£186	£4,157	£19,343
33kV Fittings	£227	£1,508	£96	£267	£2,098
66kV Fittings	£292	£1,508	£96	£533	£2,429
132kV Fittings	£485	£1,508	£96	£1,333	£3,423
33kV OHL (Tower Line) Conductor	£17,793	£1,508	£96	£1,333	£20,731
66kV OHL Conductor	£23,600	£1,508	£96	£2,667	£27,871
132kV OHL (Tower Line) Conductor	£20,408	£1,508	£96	£6,667	£28,680
HV Sub Cable	£181,996	£2	£3,600	£190,344	£375,942
33kV UG Cable (Non Pressurised)	£31,644	£2	£726	£3,530	£35,901
33kV UG Cable (Oil)	£129	£2	£5,885	£4	£6,019
33kV UG Cable (Gas)	£317	£2	£54	£35	£407
66kV UG Cable (Non Pressurised)	£64,021	£2	£726	£7,059	£71,808
66kV UG Cable (Oil)	£140	£2	£5,885	£7	£6,033
66kV UG Cable (Gas)	£519	£2	£54	£71	£645
132kV UG Cable (Non Pressurised)	£109,244	£2	£1,086	£17,648	£127,980
132kV UG Cable (Oil)	£154	£2	£7,410	£18	£7,583
132kV UG Cable (Gas)	£802	£2	£81	£176	£1,060
EHV Sub Cable	£285,322	£2	£3,600	£3,530	£292,453
132kV Sub Cable	£480,542	£2	£3,600	£17,648	£501,792
LV Circuit Breaker	£4,070	£9,109	£22	£11,085	£24,285
LV Pillar (ID)	£5,669	£9,109	£22	£8,243	£23,042
LV Pillar (OD at Substation)	£6,170	£9,109	£22	£8,243	£23,543
LV Pillar (OD not at Substation)	£3,429	£9,622	£22	£8,243	£21,316
LV UGB	£3,429	£9,622	£85	£2,748	£15,884
LV Board (WM)	£7,833	£9,109	£22	£8,243	£25,206
LV Board (X-type Network) (WM)	£9,244	£9,109	£22	£8,243	£26,617
6.6/11kV CB (GM) Primary	£7,586	£23,502	£1,547	£40,530	£73,165

Asset Register Category	Financial*	Safety*	Environmental*	Network Performance*	Total*
6.6/11kV CB (GM) Secondary	£6,959	£4,823	£1,486	£11,580	£24,848
6.6/11kV Switch (GM)	£5,267	£4,823	£1,486	£11,580	£23,156
6.6/11kV RMU	£9,839	£4,823	£1,486	£11,580	£27,728
6.6/11kV X-type RMU	£13,314	£4,823	£1,486	£11,580	£31,203
20kV CB (GM) Primary	£9,504	£23,502	£1,547	£40,530	£75,082
20kV CB (GM) Secondary	£7,214	£4,823	£1,486	£11,580	£25,103
20kV Switch (GM)	£6,104	£4,823	£1,486	£11,580	£23,993
20kV RMU	£10,024	£4,823	£1,486	£11,580	£27,912
33kV CB (Air Insulated Busbars)(ID)(GM)	£14,513	£23,502	£4,356	£29,120	£71,490
33kV CB (Air Insulated Busbars)(OD)(GM)	£17,870	£23,502	£4,356	£14,740	£60,467
33kV CB (Gas Insulated Busbars)(ID)(GM)	£21,984	£23,502	£4,356	£29,120	£78,961
33kV CB (Gas Insulated Busbars)(OD)(GM)	£21,984	£23,502	£4,356	£14,740	£64,581
33kV Switch (GM)	£10,257	£23,502	£4,356	£14,740	£52,854
33kV RMU	£25,347	£23,502	£4,356	£14,740	£67,944
66kV CB (Air Insulated Busbars)(ID)(GM)	£28,930	£23,502	£4,356	£29,120	£85,907
66kV CB (Air Insulated Busbars)(OD)(GM)	£46,252	£23,502	£4,356	£14,740	£88,849
66kV CB (Gas Insulated Busbars)(ID)(GM)	£52,176	£23,502	£4,356	£29,120	£109,153
66kV CB (Gas Insulated Busbars)(OD)(GM)	£52,176	£23,502	£4,356	£14,740	£94,773
132kV CB (Air Insulated Busbars)(ID)(GM)	£81,092	£36,171	£21,756	£153,867	£292,886
132kV CB (Air Insulated Busbars)(OD)(GM)	£38,181	£36,171	£21,756	£38,826	£134,934
132kV CB (Gas Insulated Busbars)(ID)(GM)	£168,892	£36,171	£21,756	£153,867	£380,686
132kV CB (Gas Insulated Busbars)(OD)(GM)	£168,892	£36,171	£21,756	£38,826	£265,645
6.6/11kV Transformer (GM)	£9,297	£4,823	£3,809	£4,343	£22,271
20kV Transformer (GM)	£10,585	£4,823	£3,809	£4,343	£23,560
33kV Transformer (GM)	£87,698	£23,502	£17,048	£28,940	£157,188
66kV Transformer (GM)	£134,796	£23,502	£17,048	£28,940	£204,285
132kV Transformer (GM)	£263,015	£36,171	£35,095	£230,441	£564,721

* - values rounded to nearest £ for presentation in this table

7.3 Financial Consequences

7.3.1 Overview

The Financial CoF is the cost of repair or replacement to return an asset to its pre-fault state. In the context of the Methodology, it is derived using an Asset Category Reference Financial Cost of Failure, which is then modified based on asset-specific data.

The overall process for deriving the Financial CoF is shown in Figure 22.

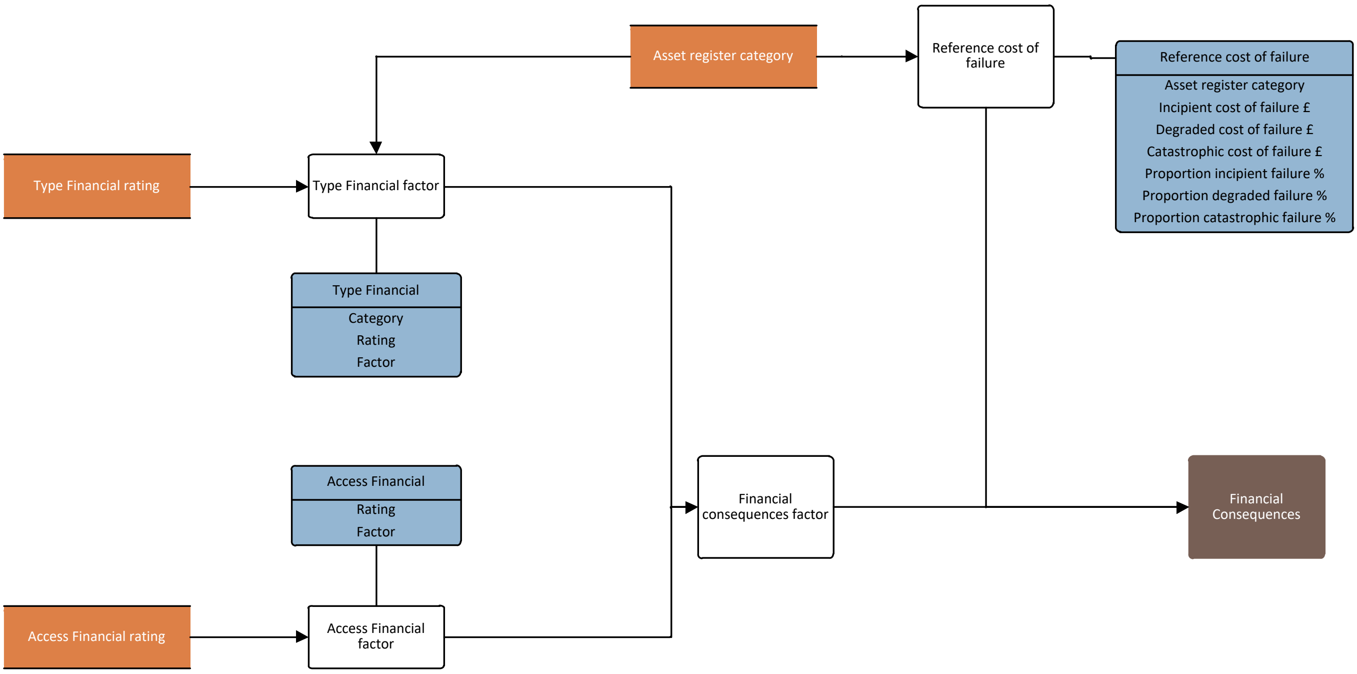

FIGURE 22: FINANCIAL COF

7.3.2 Reference Financial Cost of Failure

The Reference Financial Cost of Failure is based on an assessment of the typical replacement and repair costs incurred by a failure of the asset in each of its three failure modes; incipient, degraded and catastrophic. This assessment considers the cost of a repair in each case, and the relative proportions of failures that are associated with each failure mode, to derive a weighted average financial cost.

$$\begin{aligned}&\text{Reference Financial Cost of Failure} = \\&(\text{Proportion of Failures that are Incipient Failure} \times \text{Likely Cost of Incipient Failure}) \\&+ (\text{Proportion of Failures that are Degraded Failures} \times \text{Likely Cost of Degraded Failure}) \\&+ (\text{Proportion of Failures that are Catastrophic Failures} \times \text{Likely Cost of Catastrophic Failure})\end{aligned}$$

EQ. 27

The financial consequences framework has been built with reference to historic reported costs for repairs and replacement such that the values used represent the actual typical costs incurred by a DNO in returning a faulted asset to pre-fault serviceability.

Further detail, including the relative proportions of failures by failure type (incipient, degraded and catastrophic), used in the derivation of the Reference Financial Cost of Failure can be found in Table 218 in Appendix D. The Reference Financial Cost of Failure shown in this table, for the relevant Asset Category, shall be used to calculate the Financial CoF, for each asset.

7.3.3 Financial Consequences Factor

The Financial CoF can then be derived for individual assets by applying a Type Financial Factor and/or an Access Financial Factor to the Reference Financial Cost of Failure. This results in a Financial CoF that reflects the consequence characteristics of an individual asset of that type which may materially affect the cost of returning the asset to its pre-fault state, in comparison to what would be considered typical for the Asset Category.

$$\textbf{Financial Consequences of Failure} = \textbf{Reference Financial Cost of Failure} \times \textbf{Financial Consequences Factor}$$

EQ. 28

Where:

$$\textbf{Financial Consequences Factor} = \textbf{Type Financial Factor} \times \textbf{Access Financial Factor}$$

EQ. 29

7.3.3.1 TYPE FINANCIAL FACTOR

This Factor allows for an adjustment to be made based on considerations specific to an asset or group of assets at a sub-level of the Asset Register Category. This will typically be applied to reflect industry experience with operating specific subcategories of asset where repair and replacement costs vary from the reference cost. Lookup tables containing the criteria and values for the Type Financial Factor can be found in Table 219 in Appendix D.

7.3.3.2 ACCESS FINANCIAL FACTOR

This Factor allows for an adjustment to be made based on a consideration of access to the faulted asset, insofar as issues of access will have a direct and material influence on the scale of Financial Consequences, e.g. access to constrained sites/confined spaces. Lookup tables containing the criteria and values for the Access Financial Factor can be found in Table 220 and Table 221 in Appendix D.

7.4 Safety Consequences

7.4.1 Overview

The Safety Consequences have been derived with reference to appropriate safety regulations and guidance. The guidance for the components comprising safety consequences comes from the Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002 [Ref. 6] and associated guidance from the Health and Safety Executive (HSE) [Ref. 7]. (See Section 8.4)

The overall process for deriving the Safety CoF is shown in Figure 23.

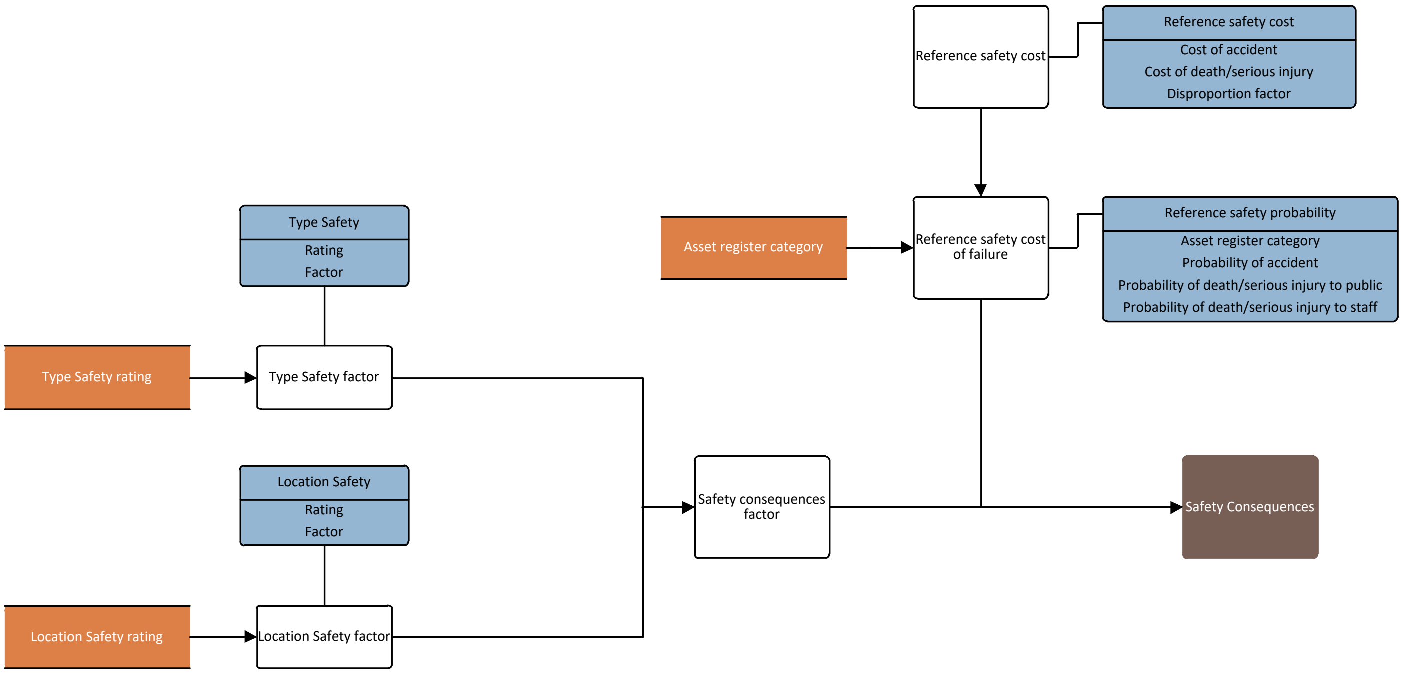

FIGURE 23: SAFETY CONSEQUENCES OF FAILURE

7.4.2 Reference Safety Cost of Failure

The Reference Safety Cost of Failure is derived initially by applying the probability that a failure could result in an accident, serious injury or fatality to the cost of a Lost Time Accident (LTA) or Death or Serious Injury (DSI) as appropriate.

$$\textbf{Reference Safety Cost of Failure} = ((\textbf{Probability of LTA} \times \textbf{Cost of LTA}) + ((\textbf{Probability of DSI to the Public} + \textbf{Probability of DSI to the Staff}) \times (\textbf{Cost of DSI})) \times \textbf{Disproportion Factor}$$

EQ. 30

Where:

- *Cost of LTA is the Reference Cost of a Lost Time Accident as shown in Table 222 in Appendix D*
- *Cost of DSI is the Reference Cost of a Death or Serious Injury as shown in Table 222 in Appendix D*
- *Disproportion Factor is explained later in this section*

Each Asset Category has an associated reference safety probability based on applying the appropriate value (of preventing a LTA or DSI) to the corresponding probability that each of these events occurs, categorised as follows:-

i) LTA;
ii) DSI to member of staff; and
iii) DSI to member of the public.

These values have been derived from an assessment of both disruptive and non-disruptive failure probabilities for these events based on bottom up assessments of faults. These have been evaluated for each Asset Category and are:-

i) probability that event could be hazardous;

ii) probability that person who is present suffers the effect; and
iii) probability that affected person is present when fault occurs.

The Reference Safety Cost of Failure uses costs for 'death or serious injury' and 'accident' that are based on the HSE's GB cross-industry wide appraisal values for fatal injuries and for non-fatal injuries [Ref. 7]. These represent a quantification of the societal value of preventing a fatality or lost time accident. The same valuation of costs for 'death or serious injury' and 'accident' has been used in the derivation of the Reference Safety Cost of Failure for all Asset Categories.

In addition, a Disproportion Factor recognising the high-risk nature of the electricity distribution industry is applied. Such factors are described by the HSE guidance when identifying reasonably practicable costs of mitigation [Ref. 8]. This value is not mandated by the Health and Safety Executive (HSE), but they state that they believe that "the greater the risk, the more should be spent in reducing it, and the greater the bias should be on the side of safety". They also suggest that the extent of the bias must be argued in the light of all the circumstances and that the factor is unlikely to be higher than 10. In the Methodology, the factor is set to 6.25 (see Table 223), which serves to cap the current value of preventing a fatality at around £11m.

This work aligns to risk analysis carried out within the HSE's "Tolerability of Risk" (ToR) framework [Ref. 9].

Further detail including the probabilities of Lost Time Accidents and Death or Serious Injury and the values for Reference Safety Cost can be found in Appendix D. The cost of an LTA and the cost of a DSI are common for all asset types.

7.4.3 Safety Consequences Factor

The Methodology includes the ability to vary the Safety CoF for an individual asset around the Reference Safety Cost of Failure for its type, based on a consideration of two additional factors; the Type Safety Factor and the Location Safety Factor. These are designed to capture the specific circumstances of individual assets insofar as they are likely to have a material impact on the safety consequences of any failure of the asset and are applied as a combined Safety Consequences Factor to the Reference Safety Cost of Failure. This is shown in EQ. 31.

$$\text{Safety Consequences of Failure} = \text{Reference Safety Cost of Failure} \times \text{Safety Consequences Factor} \times \text{Safety Risk Reduction Factor}$$

EQ. 31

Where:

- *The Safety Consequences Factor is derived using a lookup value from the location/type matrix shown in Table 225 & Table 226, applying the criteria shown in Section D.2 of Appendix D and an additional Safety Risk Reduction Factor is applied as shown in Table 227.*

The requirement to undertake assessments of this type is stated in the ESQCR and the guidance below is adapted from the guidance associated with the regulations.

7.4.3.1 TYPE SAFETY FACTOR

This addresses the principal characteristics of the equipment and its siting.

This can include reflection of the “Nature and situation of equipment” category within the ESQCR risk assessment. Generally, equipment comprising exposed conductors will be higher risk in view of the consequences of persons coming into contact with that equipment. Plant which is fully insulated, or metal enclosed will generally be lower risk. Equipment or plant which is likely to be attractive to vandals or thieves (e.g. terminal Towers) will generally be higher risk than plant which is less attractive to such persons (e.g. single wood poles).

Another characteristic considered for switchgear is the interruption medium and arc flash protection as oil filled switchgear failures can be explosive.

7.4.3.2 LOCATION SAFETY FACTOR

This is taken from the “Nature and situation of surrounding land” test in the ESQCR risk assessment. Here duty holders are required to take a view of the risk of danger from interference with the equipment - whether wilful or accidental - in consideration of the environment in which the equipment is placed.

There are two aspects to this test: firstly, the geography of the land and its features (for example forests, rivers, flat fields, motorway, city streets) and secondly the use of the land (for example agricultural machinery, recreational areas, schools, housing estate).

For example, electrical equipment in housing estates or in close proximity to unsupervised recreational playing fields will generally be at higher risk of danger from interference than equipment situated on sparsely populated land or contained within occupied premises.

7.5 Environmental Consequences

7.5.1 Overview

The Environmental Consequences have been derived with reference to appropriate environmental regulations and stakeholders.

The overall process for deriving the Environmental CoF is shown in Figure 24.

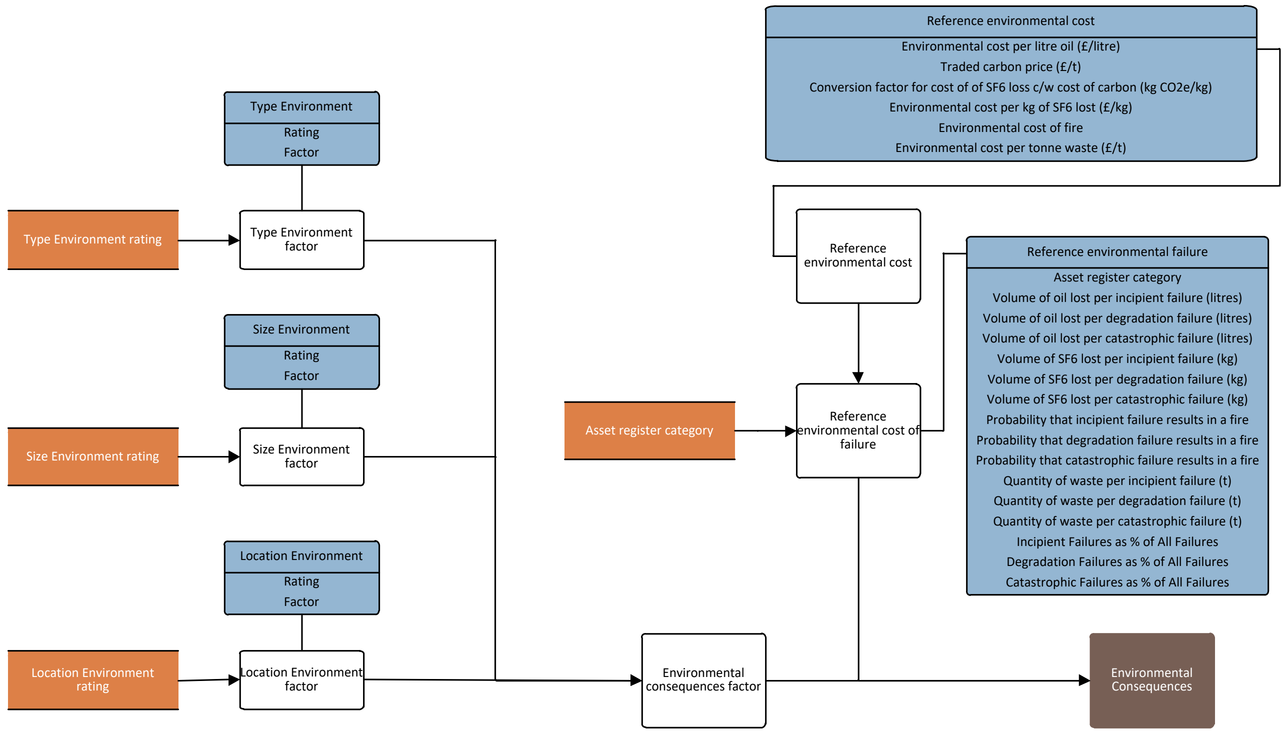

FIGURE 24: ENVIRONMENTAL CONSEQUENCES OF FAILURE

7.5.2 Reference Environmental Cost of Failure

The Environmental CoF value for an asset is derived using a Reference Environmental Cost of Failure, which is modified for individual assets using asset-specific factors. This is based on an assessment of the typical environmental impacts of a failure of the asset in each of its three failure modes; incipient, degraded and catastrophic. The Reference Environmental Cost of Failure that shall be used for each Asset Category is shown in Table 228 in Appendix D.

This assessment considers four factors;

i) Volume of oil lost;
ii) Volume of SF_6 lost;
iii) Probability of the event leading to a fire; and
iv) Quantity of waste produced.

$$\begin{aligned}
&\textbf{Reference Environmental Cost of Failure} = (\textbf{\% of Incipient Failures}) \times \\
&((\textbf{Volume of oil lost per Incipient failure} \times \textbf{Environmental cost per litre oil (£/litre)}) + \\
&(\textbf{Volume of } SF_6 \textbf{ lost per Incipient failure} \times \textbf{Environmental cost per kg of } SF_6 \textbf{ lost (£/kg)}) + \\
&(\textbf{Probability of failure leading to a fire per Incipient failure} \times \textbf{Environmental cost of fire}) + \\
&(\textbf{Quantity of waste produced per incipient failure} \times \textbf{Environmental cost per tonne waste (£/t)})) + \\
&(\textbf{\% of Degraded Failures}) \times ((\textbf{Volume of oil lost per Degraded failure} \times \\
&\textbf{Environmental cost per litre oil (£/litre)}) + (\textbf{Volume of } SF_6 \textbf{ lost per Degraded failure} \times \\
&\textbf{Environmental cost per kg of } SF_6 \textbf{ lost (£/kg)}) + \\
&(\textbf{Probability of failure leading to a fire per Degraded failure} \times \textbf{Environmental cost of fire}) + \\
&(\textbf{Quantity of waste produced per Degraded failure} \times \textbf{Environmental cost per tonne waste (£/t)})) + \\
&(\textbf{\% of Catastrophic Failures}) \times ((\textbf{Volume of oil lost per Catastrophic failure} \times \\
&\textbf{Environmental cost per litre oil (£/litre)}) + (\textbf{Volume of } SF_6 \textbf{ lost per Catastrophic failure} \times \\
&\textbf{Environmental cost per kg of } SF_6 \textbf{ lost (£/kg)}) + \\
&(\textbf{Probability of failure leading to a fire per Catastrophic failure} \times \textbf{Environmental cost of fire}) + \\
&\textbf{Quantity of waste produced per Catastophic failure} \times \textbf{Environmental cost per tonne waste (£/t)})))
\end{aligned}$$

EQ. 32

Where:

- *Environmental cost per litre oil = £43.35/litre*
- *Environmental cost per kg of SF_6 lost = £1,723/kg*
  Which is derived from:
  - *Traded carbon price = £72.10/tonne*
  - *Cost of SF_6 loss c/w cost of carbon = 23,900kg(CO_2)/kg*
- *Environmental cost of fire = £6,007*
- *Environmental cost per tonne waste = £180/tonne*

The sources for the above costs are shown in Table 17.

TABLE 17: SOURCES OF INFORMATION FOR ENVIRONMENTAL REFERENCE CASE

Fixed value	Source
Environmental cost per litre oil (£/litre)	This is derived from the EU trading value for carbon emissions and is consistent with the value used in Ofgem's RIIO-ED2 Cost Benefit Analysis template (used for the RIIO-ED2 submissions) (at 2020/21 prices)
Traded carbon price (£/t)	Traded carbon price for 2028 from central scenario in Department for Business, Energy & Industrial Strategy's published 'Updated Short-Term Traded Carbon Values used for UK public policy appraisal (2018)' document (inflated to 2020/21 prices) – see https://www.gov.uk/government/publications/updated-short-term-traded-carbon-values-used-for-uk-policy-appraisal-2018
Conversion factor for cost of SF_6 loss c/w cost of carbon (kg CO_2e/kg)	2011/12 Defra conversion factor

7.5.3 Environmental Consequences Factors

The Methodology includes the ability to vary the Environmental Consequences value for an individual asset around the Reference Environmental Cost of Failure for its type, based on a consideration of three additional factors; the Type Environmental Factor, the Size Environmental Factor and the Location Environmental Factor. These are designed to capture the specific circumstances of individual assets insofar as they are likely to have a material impact on the Environmental Consequences of any failure of the asset and are applied as a combined Environmental Consequences Factor on the Reference Environmental Cost of Failure.

$$\text{Environmental Consequences of Failure} = \text{Reference Environmental Cost of Failure} \times \text{Environmental Consequences Factor}$$

EQ. 33

Where:

$$\text{Environmental Consequences Factor} = \text{Type Environmental Factor} \times \text{Size Environmental Factor} \times \text{Location Environmental Factor}$$

EQ. 34

7.5.3.1 TYPE ENVIRONMENTAL FACTOR

This Factor allows for an adjustment to be made based on considerations specific to an asset or group of assets at a sub-level of the Asset Register Category. As the Reference Environmental Cost of Failure is built up using the impact from oil & SF_6 the Type Environmental Factor is used to temper the effects for each switchgear type. The modifier values for the Type Environmental Factor can be found in Table 229 in Appendix D.

7.5.3.2 SIZE ENVIRONMENTAL FACTOR

This Factor allows for an adjustment to be made based on a consideration of the size of the asset in question, insofar as the size has a direct and material influence on the scale of Environmental Consequences, e.g. a larger than average Transformer holding a greater quantity of oil than that assumed in the reference case for that asset type. The modifier values for the Size Environmental Factor can be found in Table 230 in Appendix D.

7.5.3.3 LOCATION ENVIRONMENTAL FACTOR

This Factor allows for an adjustment to be made based on an assessment of the environmental sensitivity of the site on which an asset is located. The specific concerns will vary by asset type but include proximity to watercourses and other environmentally sensitive areas. The Factor also recognises any mitigation associated with the asset. The modifier values for the Location Environmental Factor can be found in Table 231 in Appendix D. This Factor is derived by combining separate Factors relating to proximity to a watercourse (Proximity Factor) and the presence of a bund (Bunding Factor) as shown in EQ. 35.

$$\text{Location Environment Factor} = \text{Proximity Factor} \times \text{Bunding Factor}$$

EQ. 35

7.6 Network Performance Consequences

7.6.1 Overview

The Network Performance CoF for an asset is derived from one of two approaches, depending on the voltage of the asset considered. For all assets operating at 20kV and below, the LV & HV Asset Consequences process is followed. For all assets operating above 20kV, the EHV & 132kV Asset Consequences process is followed.

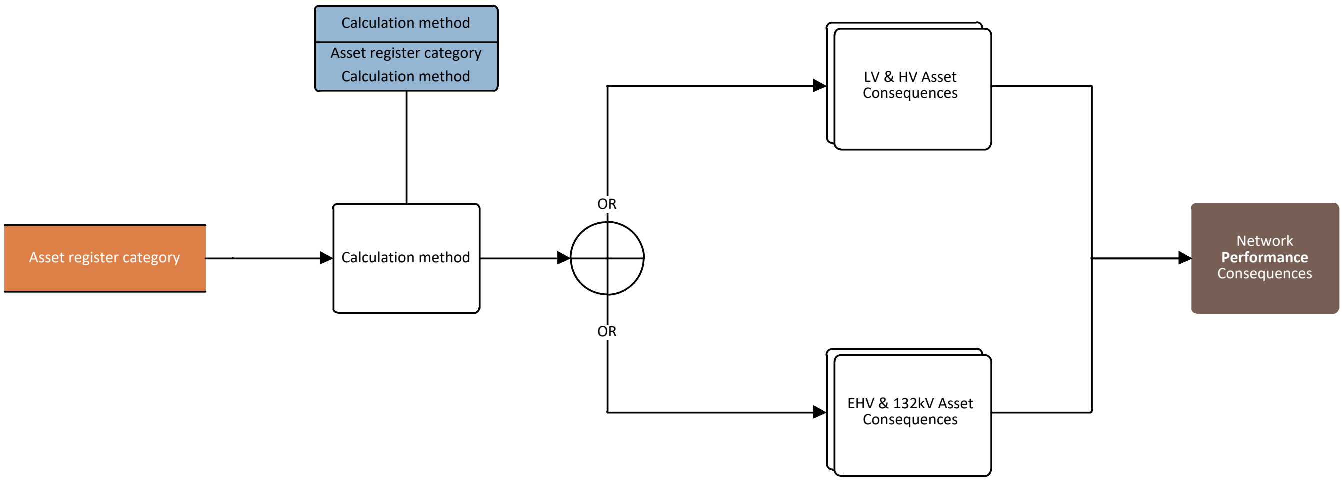

FIGURE 25: NETWORK PERFORMANCE CONSEQUENCES OF FAILURE

7.6.2 Network Performance Consequences (LV & HV)

For LV and HV assets, a Reference Network Performance Cost of Failure appropriate to the Asset Category is initially applied. The resulting value can then be modified for individual assets in two ways:-

i) directly, based on the ratio of customers connected to an individual asset to the equivalent figure used in the average value; and/or

ii) via the application of a Customer Sensitivity Factor to reflect customer characteristics (if appropriate).

Applying these Factors results in an LV or HV Asset Consequence value that reflects the network consequence characteristics of an individual asset of that type.

The overall process for deriving the Network Performance CoF is shown in Figure 26.

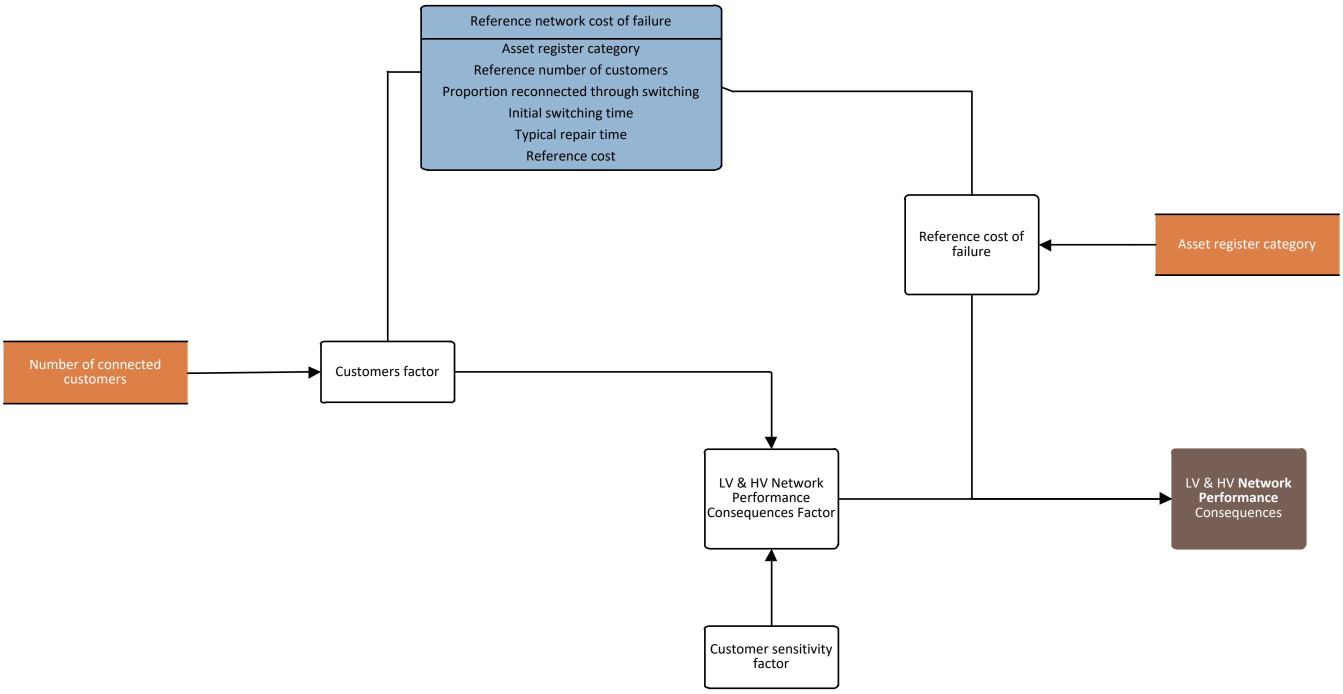

FIGURE 26: NETWORK PERFORMANCE ASSET CONSEQUENCES OF FAILURE (LV & HV)

7.6.2.1 REFERENCE NETWORK PERFORMANCE COST OF FAILURE (LV & HV)

The Reference Network Performance Cost of Failure is based on an assessment of the typical network costs incurred by a failure of the asset as measured through its impact in relation to the number of customers interrupted and the duration of those interruptions. For regulatory purposes, this is captured via the IIS mechanism.

An assessment is made of the typical numbers of customers interrupted by a failure, and the typical time to restore all supplies. This is based on a typical number of customers being connected to the section of distribution network that would be affected by failure of the asset (the Reference Number of Connected Customers).

The numbers of customers interrupted and customer minutes without supply are evaluated and multiplied by the relevant cost of a customer interruption (Cost of CI) and cost of a customer minute lost (Cost of CML) to produce a typical cost per failure for a given Reference Number of Connected Customers.

$$\begin{aligned}&\textbf{Reference Network Performance Cost of Failure} =\\&[(\textbf{Cost of CML} \times 60 \times \textbf{Reference Number of CC} \times \textbf{Switching Time} \times (100\% \\&\quad - \%\ \textbf{of CC restored through immediate switching}))\\&+ (\textbf{Cost of CML} \times 60 \times \textbf{Reference Number of CC} \times \textbf{Restoration Time} \times (100\% -\\&\%\ \textbf{of CC restored after manual switching}))\\&+ (\textbf{Cost of CI} \times \textbf{Reference Number of CC} \times (100\% -\\&\%\ \textbf{of CC restored through immediate switching}))] \times \%\ \textbf{of failures that result in}\\&\textbf{interruption to supply}\end{aligned}$$

EQ. 36

Where:

- *CC = Connected Customers*
- *Switching Time and Restoration Time are durations (in hours)*

Further explanation on the derivation of the values for the Reference Network Performance Cost of Failure (LV & HV) can be found in section D.4.1 in Appendix D. The values of Reference Network Performance Cost of Failure (LV & HV) by Asset Category can be found in Appendix D.

7.6.2.2 NETWORK PERFORMANCE FACTORS (LV & HV)

The Reference Network Performance Cost of Failure can then be modified on an asset by asset basis as shown in EQ. 37.

$$\text{Network Performance Cost of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Network Performance Consequence Factor}$$

EQ. 37

Where:

$$\text{Network Performance Consequence Factor} = \text{Customer Factor} \times \text{Customer Sensitivity Factor}$$

EQ. 38

Customer Factor

This Factor is used to reflect the number of customers impacted by failure of an individual asset, relative to the reference number of customers used in the derivation of the Reference Network Performance Cost of Failure.

This is applied as a direct Factor, i.e. not via a lookup table. For example, if the number of customers used in the derivation of the Reference Network Performance Cost of Failure is 100, but for a specific example it is 80 (or 120), then a modifying factor of 0.8 (or 1.2) would be applied.

$$\text{Customer Factor} = \frac{\text{No. of Customers}}{\text{Reference No. of Customers}}$$

EQ. 39

Where a DNO identifies that the customers fed by an individual asset have an exceptionally high demand per customer, then the No. of Customers used in the derivation of EQ. 39 may be derived by applying an adjustment to the actual number of customers fed by the asset as shown in Table 18. This adjustment recognises that for high demand customers the cost of a customer interruption and a customer minute lost may not reflect the value of lost load to the customer. DNOs can elect whether to apply this adjustment within their implementation of the Methodology.

TABLE 18: CUSTOMER NUMBER ADJUSTMENT FOR LV & HV ASSETS WITH HIGH DEMAND CUSTOMERS

Maximum Demand on Asset / Total Number of Customers fed by the Asset (kVA per Customer)	No. of Customers to be used in the derivation of Customer Factor
< 50	1 x actual number of customers fed by the asset
≥ 50 and < 100	25 x actual number of customers fed by the asset
≥ 100 and < 500	100 x actual number of customers fed by the asset
≥ 500 and < 1000	250 x actual number of customers fed by the asset
≥ 1000 and < 2000	500 x actual number of customers fed by the asset
≥ 2000	1000 x actual number of customers fed by the asset

The default value for the Customer Factor is 1.

Customer Sensitivity Factor

The Customer Sensitivity Factor is used to reflect circumstances where the customer impact is increased due to customer reliance on electricity (e.g. vulnerable customers). DNOs may use this factor at their discretion in order to modify the Network Performance Consequence Factor.

The default value for the Customer Sensitivity Factor is 1. Individual DNOs are provided with the freedom within the Methodology to apply a Customer Sensitivity Factor, other than the default, to the Network Performance Consequences (LV & HV) for any asset, provided that:-

i) the individual DNO documents all instances where a Customer Sensitivity Factor different from the default is applied within their individual Network Asset Indices Methodology; and
ii) The Customer Sensitivity Factor shall not be less than 1, nor greater than 2.

7.6.3 Network Performance Consequences (EHV & 132kV)

Similarly, for EHV and 132kV assets, asset-specific Network Performance Consequence Factors are applied to the Reference Network Performance Cost of Failure in order to calculate the Network Performance Consequences associated with an individual asset.

For these assets, the Methodology reflects the fact that redundancy is usually designed into networks at these voltages due to the size of demand group they supply.

A significant proportion of these networks are constructed so that the supply to customers is secure for a single outage of any circuit within the network. For the purposes of the Methodology a network shall be considered secure if, in the event of a first circuit outage, there is either no interruption of supply to customers or supply is restored immediately through automatic switching as defined in ENA Engineering Recommendation P2/6 (‘Security of Supply’).

Once a first circuit outage has occurred within a secure network, there may be parts of the network that would experience a loss of supply if a further circuit outage were to occur. The load that could be expected to be impacted (i.e. would experience a loss of supply) during such a further circuit outage is referred to as Load at Risk.

Within EHV and 132kV networks, there may also be some parts of the network where the supply to customers is not secure for a first circuit outage event. In such cases, a first circuit outage will directly impact any connected customers and restoration is achieved via switching in line with the timescales specified in Engineering Recommendation P2/6 for that demand group.

The methodology for determining Network Performance Consequences for EHV and 132kV assets enables both these types of network to be recognised.

The overall process for deriving the Network Performance Cost of Failure is shown in Figure 27.

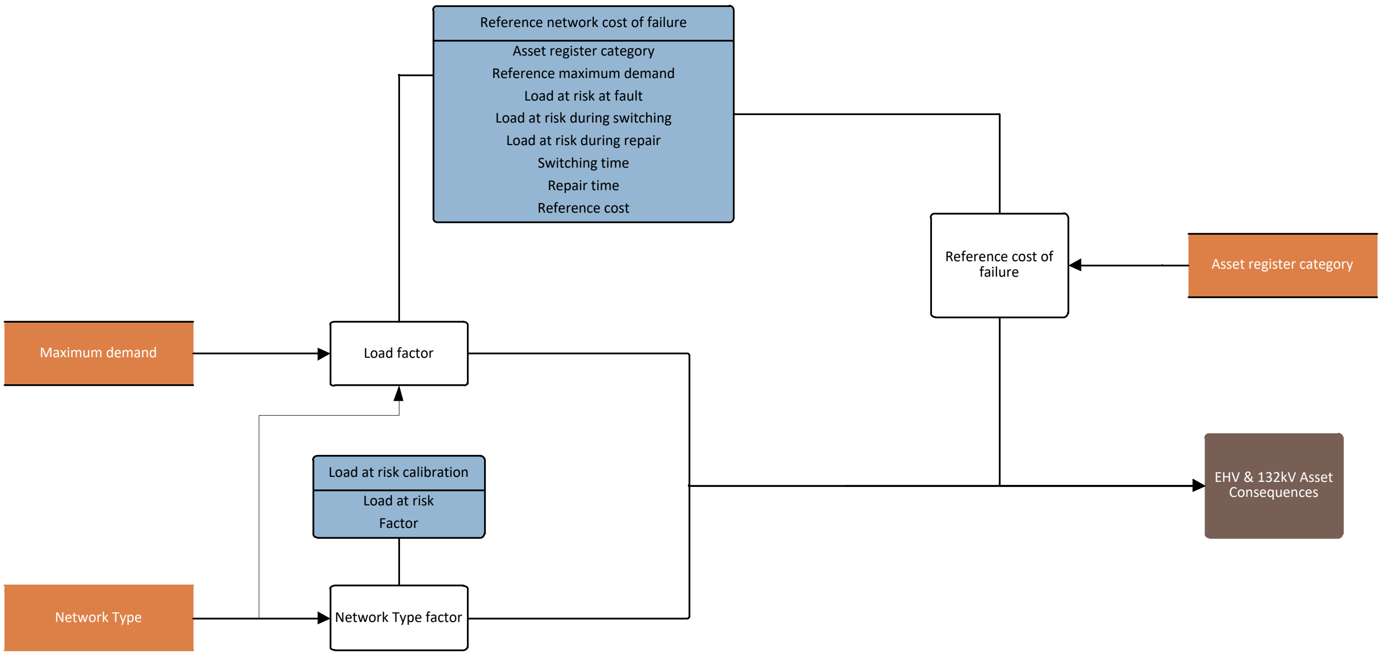

FIGURE 27: NETWORK PERFORMANCE CONSEQUENCES OF FAILURE (EHV & 132KV)

7.6.3.1 REFERENCE NETWORK PERFORMANCE COST OF FAILURE (EHV & 132KV)

The Reference Network Performance Cost of Failure is based on an assessment of the amount of Load at Risk during three stages of failure, and the typical duration of each stage:

i) During fault (T1): this is the time-period between initial circuit protection trip operation and automatic switching to reconfigure the network;
ii) During initial switching (T2): this is the time-period during which further manual network switching is undertaken to reconfigure the network to minimise the risk associated with a further circuit outage; and
iii) During repair time (T3).

The Load at Risk is evaluated based on a typical value of maximum demand under normal running conditions.

The load at risk is then multiplied by the relevant Value of Lost Load (VoLL) figure to derive a typical Reference Network Performance Cost of Failure for these assets, taking account of the probability of a further circuit outage.

$$\text{Reference Network Performance Cost of Failure} = \big((\text{Load at risk in T1} \times \text{Duration of T1}) + (\text{Load at risk in T2} \times \text{Duration of T2}) + (\text{Load at risk in T3} \times \text{Duration of T3})\big) \times \text{\% of failures that result in an unplanned outage} \times \text{Probability of further coincident outage} \times \text{VoLL}$$

EQ. 40

The value of VoLL used is consistent with the values for Cost of CI and Cost of CML used in the evaluation of the Reference Network Performance Cost of Failure for LV and HV assets. Therefore, the evaluation of the Reference Network Performance Cost of Failure for EHV and 132kV assets is consistent with the evaluation of the impact in distribution assets.

Further explanation of the derivation of the Reference Network Performance Cost of Failure for EHV and 132kV assets can be found in Section D.4.3 in Appendix D.

7.6.3.2 NETWORK PERFORMANCE FACTORS (EHV & 132KV)

The Network Performance CoF is derived on an asset by asset basis as shown in EQ. 41.

$$\text{Network Performance Consequences of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Load Factor} \times \text{Network Type Factor}$$

EQ. 41

Load Factor

This Factor allows for the Network Performance CoF to reflect the actual load at risk associated with the failure of the asset under consideration, relative to the value of maximum demand used to create the reference value.

The Load Factor is determined as shown in EQ. 42 (i.e. not via a lookup table).

$$\text{Load Factor} = \frac{\text{Actual Load at Risk Associated with the Failure of the Asset Under Consideration}}{\text{Maximum Demand Used To Derive Reference Network Performance Cost of Failure}}$$

EQ. 42

For example, if the Reference Network Performance Cost of Failure has been derived using a reference maximum demand of 12MVA, but for a specific asset the actual load at risk was 6MVA then a Load Factor of 0.5 would be applied.

The values of maximum demand used in derivation of the Reference Network Performance Cost of Failure can be found in Table 235 in Appendix D.

Where the actual load is not known, the default value for Load Factor is dependent on the security of supply of the associated network.

A default Load Factor of 0.5 shall be applied where an individual asset is located in a network that is not secure for a first circuit outage event that would result from failure of the asset (i.e. the network would be considered not secure if the load normally supplied by the asset would be interrupted and not restored automatically, in such an event).

A default Load Factor of 1 shall apply to assets in secure networks or where the security of the network is unknown.

Network Type Factor

This Network Performance CoF is derived on an asset by asset basis by the application of a Network Type Factor to take account of the security of supply afforded by the topology of the network in which the individual asset is located.

A Network Type Factor of 2.5 shall be applied where an individual asset is located in a network that is not secure for a first circuit outage event that would result from failure of the asset (i.e. the network would be considered not secure if the load normally supplied by the asset would be interrupted and not restored automatically, in such an event).

A Network Type Factor of 1 shall apply to assets in secure networks.

The default value for Network Type Factor is 1.

8. REFERENCES

8.1 A Note on Referencing

The content in many of the tables consists of factors and values which were decided (by agreement or by calculation) by internal working group agreement. There are also a number of table values determined by the RIGs. Where the values have been dictated otherwise or by external sources there is an associated numbered reference.

This section of the document lists the external references and explains which tables require an external reference. It also describes, where that is not the case, what is meant by the reference to an “internal working group agreement”.

8.2 Reference to Internal Working Group Agreement

Decisions governing these values were made during a model calibration exercise in 2015 which pragmatically captured engineering experience and reliability-based concepts. Every table in the document was fully examined and discussed by the group.

The choice of the factors themselves came from DNO shared information about what factors existed in their current CBRM models. These models were built within the DNOs over the previous two decades. The principles guiding the decision included ensuring that DNOs collecting more information than others were not held back from continuing to do so, and to avoid duplication of factors that in essence indicated the same degradation mechanism.

The parameters for combination were also agreed collectively based on similar principles, so that while DNOs collecting more information than others should not be prevented from using their better information, DNOs collecting less should not be put in a position of not being able to achieve the kinds of Health Scores that accurately described their poorest assets. Hence the use of an MMI approach. The number of factors that can be combined also related to the number of existing factors for an asset category.

In terms of calibrating the weightings, experience with current models was drawn upon in situations where the combination method was the same as that for common methodology. The results of testing were then used so that if entire populations were tending to bias at one extreme, the weightings were revised to make sure that they resulted in a spread that was reasonable.

8.3 Table Reference Breakdown

Table 1,Table 2 and Table 3 summarise asset categories governed by the RIGs. This is referred to in the descriptive text above the tables.

The failure type descriptions in Table 4 were agreed by the working group.

Table 5 and Table 6 show the PoF bandings and were agreed by the working group. The calibration exercise for these considered the speed at which an asset moves through each band and judged that against engineering experience.

Table 7 shows the CoF bandings. It is governed by the RIGs and comes out of previous work by the Asset Health and Criticality working group that was incorporated in the RIGs for the RIIO-ED1 business plan submissions.

Table 8 to Table 15 show PoF factors for each of location, duty and condition; and parameter information for combining these factors within the methodology. These values were agreed by the working group.

Table 16 to Table 18 relate to CoF. Table 16 is merely a summary of the Reference Costs of Failure which are described in detail in the Appendix D tables. As CoF values are very much governed by external sources of information there are appropriate references to these in the descriptive text along with Table 17 which explicitly lists the environmental sources. Table 18 shows customer bandings agreed by the working group.

Table 19 shows Functional Failure Definitions agreed by the working group. In this case agreement was based on an information gathering exercise across the DNOs of failure information derived from risk management over many years, including failure modes and effects analysis and a familiarity with the history of defects and faults for each asset category.

Table 20 summarises asset lives as agreed by the working group following an information sharing exercise. Where there was a wide range in the same asset category the group looked at the mix of asset types that was driving the difference and determined appropriate sub-types accordingly. Work on asset lives was carried out in substantial detail in DNOs going back to before DPCR4 and they have been used and updated in annual RRP submissions during DPCR5 and RIIO-ED1.

Table 21 shows PoF curve parameters which were calculated by the working group. Their derivation is described in Section 6.1.2 and they come from shared DNO data consisting of the observed number of functional failures for each asset category per annum, considering Incipient, Degraded and Catastrophic Failures; from the 2014/15 Health Index distributions; and from the total volumes of assets within the population.

Table 22 to Table 34 show location and Duty Factors and calibrations agreed by the working group.

Table 35 to Table 202 show Observed Condition and Measured Condition Factors and calibrations which were agreed by the working group. The decisions for these were based on a combination of obvious logical rules, engineering experience, and testing using the common methodology spreadsheet models. The obvious logical rules are that:-

i) The maximum factor value will not push the Current Health Score above its cap of 10;
ii) Weightings reflect condition so that, for example, a poor state will have a higher weighting than a moderate state for example;
iii) The distance between two states describe the engineering conditions so for example, if corrosion indicating structural damage is much more serious than corrosion indicating cosmetic damage then the weightings have a proportionate distance between them.
iv) The number of states is calculable and meaningful and in sync with DNO data collection.
v) Improvement factors are also appropriate in situations where signs of wear would have been expected indicating a Health Score better than initially indicated from age and expected life.
vi) There should be a spread across Health Index bands within a representative asset population.

For the measured condition factor values it was also recognised that the condition criteria tend to be a function of how results from the test equipment are categorised in practice. For example, partial discharge typically might have a high, medium and low result.

Table 203 to Table 215 relate to transformer oil sampling and are covered by external references 3 to 5.

Table 216 is for the Ageing Reduction Factors and the basis for these is covered by reference 2.

Table 217 in Appendix C is covered by the RIGs working group for the categories and the working group agreed what HI factors were affected by the intervention.

Table 218 to Table 235 in Appendix D show the Criticality Factors, their Reference Cost of Failure values, and how asset specific factors are weighted. Environmental, Safety and Network Performance Consequence Factors and criteria reference external sources as is already well described in Section 7. Financial Consequence Factors came from working group agreement based on an understanding of the Financial Factors at play in practice in the different DNOs.

The reference values are derived as described in Section 7, so the tables just show the results of calculations carried out using the externally given costs and the working group agreed assumptions about derivation.

Calibration decisions for the asset specific factors were made collectively by the working group, based on the logic that as things get more critical their weightings increase in a way that is proportionate to the underlying engineering criticality being described.

Table 236 to Table 241 in Appendix E show the reference values associated with the CoF and PoF weightings for the Criticality Index and Health Index bands as well as the Risk Matrix weightings, typical forecast ageing rates all referenced in Section 5 with regard to the calculated Risk Index associated with the Long Term Risk.

8.4 Document References

1. RIIO-ED2 Business Plan Data Template - Glossary (31 March 2021) https://www.ofgem.gov.uk/system/files/docs/2021/04/ed2_bpdts_-_glossary_v6.pdf
2. Reliability Centred Maintenance, John Moubray, 1991, Butterworth Heinemann.
3. BS EN 60422:2013 “Mineral insulating oils in electrical equipment — Supervision and maintenance guidance”
4. Expert System for Assessing Transformer Condition, EA Technology Report No. 4969, Project S0446, (M Black, J R Brailsford, D Hughes & M I Lees Sept 1999)
5. BS EN 60599:1999 “Mineral oil-impregnated electrical equipment in service — Guide to the interpretation of dissolved and free gases analysis”
6. Electricity Safety, Quality and Continuity Regulations 2002, as amended in 2006 (ESQCR). http://www.legislation.gov.uk/uksi/2002/2665/contents/made
7. Current HSE cost models. HSE: Appraisal values or 'unit costs' (2018)
8. Current guidance about what should and should not be considered in a duty holder’s cost benefit analysis (CBA) for health and safety ALARP determinations. http://www.hse.gov.uk/risk/theory/alarpcheck.htm
9. Reducing risks, protecting people - HSE’s decision-making process (first published in May 1999). http://www.hse.gov.uk/risk/theory/r2p2.pdf
10. The National Galvanizers Association - https://www.galvanizing.org.uk/corrosion-map/
11. HM Treasury publications:
    The Green Book (2020)
    Update Short-Term Traded Carbon Values (2019) : Table 1 Central
    Greenhouse gas reporting: Conversion Factors 2020 - condensed set (for most users)
    Guidance on estimating carbon values beyond 2050: an interim approach

APPENDIX A
FUNCTIONAL FAILURE DEFINITIONS

TABLE 19: FUNCTIONAL FAILURE DEFINITIONS

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
LV Circuit Breaker	Measure and break unsafe levels of current (over current), make load current, and provide a point of electrical isolation.	Failing to open on a fault. Failing to close reliably. Failing to open during manual operation. Failure to supply load current (i.e. failure during normal operating conditions). Opens Spuriously under normal conditions. Opens Intermittently (Faulty).	Failure of Housing. Disruptive Failure Resulting from Insulation Breakdown.	Nuisance tripping or failure to operate when required due to: - damage to contacts - loose internal connections -Damage to mechanism and drive rods.	Nuisance tripping or failure to operate when required due to: - Maladjusted linkage.	Failure of protection module. Failure of SCADA.
LV Pillar (ID) LV Pillar (OD at Substation / LV Pillar (OD not at a Substation)	Provide a number of points of access to LV Cable Systems for electrical connection, isolation and flexibility with network reconfiguration. Depending on the complexity of pillar they may also offer monitoring and protection (fuse or circuit breaker) capabilities.	Failing to close reliably. Failing to open during manual operation. Failure to supply load current (i.e. failure during normal operating conditions).	Failure of Housing. Disruptive Failure Resulting from Insulation Breakdown requiring the replacement of one or all ways.	Failure of Housing requiring repair. Nuisance tripping or Failure of an LV Pillar's Fuse, MCB or RCBO to operate when required due to: - deteriorated fuse carriers - breaker stuck closed.	Nuisance tripping or Failure of an LV Pillar's Fuse, MCB or RCBO to operate when required due to: - incorrect fuse/breaker rating - breaker not latching closed.	Contact damage due to incorrect operation of board.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
LV Board (WM)	Provide a number of points of access to LV Cable Systems for electrical connection, isolation and flexibility with network reconfiguration. Depending on the complexity of LV Board, they may also offer monitoring and protection (fuse or circuit breaker) capabilities.	Failing to open on a fault. Failing to close reliably. Failing to open during manual operation. Failure to supply load current (i.e. failure during normal operating conditions). Opens Spuriously under normal conditions. Opens Intermittently (Faulty).	Disruptive Failure Resulting from Insulation Breakdown.	Nuisance tripping or failure to operate when required due to: - damage to contacts - moisture ingress - deteriorated fuse carriers.	Nuisance tripping or failure to operate when required due to: - damage to contacts - loose internal connections - failure of protection module.	Failure of housing. Contact Damage due to Incorrect operation of Board.
LV UGB	Provide a number of points of access to LV Cable Systems for electrical connection, isolation and flexibility with network reconfiguration. Depending on the complexity of the LV Box, they may also offer monitoring and protection (fuse or circuit breaker) capabilities.	Failing to open on a fault (if used in this mode. Failing to close reliably. Failing to open during manual operation. Failure to supply load current (i.e. failure during normal operating conditions). Opens Spuriously under normal conditions. Opens Intermittently (Faulty).	Disruptive Failure Resulting from Insulation Breakdown.	Failure to be operable when required due to: - damage to contacts - moisture ingress - deteriorated links.	Failure to be operable when required due to: - damage to contacts - loose internal connections.	Failure of housing. Contact Damage due to Incorrect operation of Box.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
HV Switchgear (GM) – Primary / HV Switchgear (GM) - Distribution	Carry, make or break continuous load or fault current. Maintain or interrupt voltage on all three phases. Isolation & Earthing of Cables & Plant. Measurement of current and voltage.	Does not open or close on command (Where this is associated with the Breaker and not the control system). Mechanical Failure. Electrical Failure (Auxiliary & Control). Electrical Failure (Main Circuit).	Disruptive Failure Resulting from Insulation Breakdown.	SOP preventing operation. Failure to operate when required due to: - Failure of Mechanism - Protection module - CT Failure - VT Failure - Stuck Breaker.	Failure to operate when required due to: - Low Gas Lockout or Vacuum bottle condition.	Unable to withstand impulse voltage. Unable to contain the insulating medium. Does not allow switch tank to breath. Unable to support its own weight. Does not provide a connection to the substation earth mat.
EHV Switchgear (GM)	Carry, make or break continuous load or fault current. Maintain or interrupt voltage on all three phases. Isolation & Earthing of Cables & Plant. Measurement of current and voltage.	Does not open or close on command (Where this is associated with the Breaker and not the control system). Mechanical Failure. Electrical Failure (Auxiliary & Control). Electrical Failure (Main Circuit).	Disruptive Failure Resulting from Insulation Breakdown.	SOP preventing operation. Failure to operate when required due to: - Failure of Mechanism - Protection module - CT Failure - VT Failure - Stuck Breaker.	Failure to operate when required due to: - Low Gas Lockout or Vacuum bottle condition.	Unable to withstand impulse voltage. Unable to contain the insulating medium. Does not allow switch tank to breath. Unable to support its own weight. Does not provide a connection to the substation earth mat. Failure of civil structures or associated disconnectors. Any asset classed by RIG definition as EHV Switchgear Other.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
132kV Switchgear	Carry, make or break continuous load or fault current. Maintain or interrupt voltage on all three phases. Isolation & Earthing of Cables & Plant. Measurement of current and voltage.	Does not open or close on command (Where this is associated with the Breaker and not the control system). Mechanical Failure. Electrical Failure (Auxiliary & Control). Electrical Failure (Main Circuit).	Disruptive Failure Resulting from Insulation Breakdown.	SOP preventing operation. Failure to operate when required due to: - Failure of Mechanism - Protection module - CT Failure - VT Failure - Stuck Breaker.	Failure to operate when required due to: - Low Gas Lockout or Vacuum bottle condition.	Unable to withstand impulse voltage. Unable to contain the insulating medium. Does not allow switch tank to breath. Unable to support its own weight. Does not provide a connection to the substation earth mat. Failure of civil structures or associated disconnectors. Any asset classed by RIG definition as EHV Switchgear Other.
HV Transformer (GM)	Step up or step down and provide a secondary output voltage which is within statutory limits. Carry full load current when required. Carry through fault current when required.	Tapchanger, bushing, windings, core, tank or insulation failure.	Failure of the main internal components - windings, core or insulation.	Failure of the bushing, cable termination, including box and conservator tank.	Failure of the Tapchanger.	Oil condition corrected by an oil change and not re-conditioning, levels and leaks. Cable connection to controlling switchgear. Civil structure related failures.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
EHV Transformer (GM) / 132kV Transformer (GM)	Step up or step down and provide a secondary output voltage which is within statutory limits. Carry full load current when required. Carry through fault current when required.	Tapchanger, bushing, windings, core, tank, insulation or control/monitoring failure.	Failure of the tank or main internal components - windings, core or insulation.	Failure of the bushing, cable termination conservator tank and associated radiator.	Failure of the Tapchanger.	Oil condition corrected by an oil change and not re-conditioning, levels and leaks. CT's, VT's and on tank unit auxiliary transformers associated with the unit NER's and NEX's Neutral displacement VT's. Cable and busbar connection to controlling switchgear. Civil structure related failures. Buchholz.
Poles	Support electrical equipment in compliance with the ESQCR and Construction Regulations.	Decayed Pole. Decayed Struts. Snapped Stays.	Any structure whose components have either failed (broken) or whose residual strength has decreased to a level where immediate replacement of all or part of the structure is required.	Any structure whose components have a residual strength such that replacement is required within the timescale defined by the Company.	Vermin Damage resulting in Factor of Safety reduction requiring an intervention.	Broken Conductor. Broken or damaged fittings. Damaged or non-functioning plant. Broken or damaged insulation. Missing or degraded safety signs and anti climbing fixtures. Leaning poles where statutory clearances are not impacted. Cable boxes and platforms, including sealing ends.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
Towers	Support electrical equipment in compliance with the ESQCR.	Corrosion or distortion of the structure, i.e. bent member, failing foundations.	Any structure whose components have either failed (broken) or whose residual strength has decreased to a level where immediate replacement of all or part of the structure is required.	Any component of the structure whose condition is such that it prevents normal operation of the Tower, or degrades the residual strength of the Tower, requiring an intervention with in a defined period.	Corrosion to minor Tower components and land movements degrading the potential of the Towers stability.	Broken Conductor. Broken or damaged fittings. Broken or damaged insulation. Missing or degraded safety signs and anti-climbing fixtures. Cable boxes and platforms, including sealing ends.
Fittings / OHL Conductor	Carry load and fault current without annealing or sagging below the ESQCR limit. Maintain continuity under normal and fault conditions. Provide phase-phase and phase-earth insulation.	Flashover. Insulation failure. Corroded Conductor. Corroded Jumper. Corroded Fitting.	Loss of structural integrity of any component associated with an overhead line supported on Steel Tower, excluding any associated Tower mounted plant, such that the residual strength of the component required immediate intervention.	Loss of structural integrity of any component associated with an overhead line supported on the Tower, excluding any associated Tower mounted plant, such that the residual strength of the component required intervention within a prescribed timescale.	Cracked insulator	Loss of protection. Loss of plant. Earthing. Any issues relating to the support, safety notices and anti-climbing guards. Conductor icing which does not result in permanent damage to the conductor. Cable boxes and platforms (including sealing ends).
Pressurised Cable	Carry load and fault current safely and reliably, without overheating or causing damage to the environment.	Oil or Gas leak / Top up. Cable Fault. Joint Failure.	Cable Fault. Joint Fault.	Accessory or joint failure causing loss of fluid.	Pressure gauges. Sheath deterioration.	Sheath damage and or repair. Third party damages.
Submarine Cables	Carry load and fault current safely and reliably, without overheating or causing damage to the environment.	Cable Fault. Joint Failure.	Cable Fault. Joint Fault.	N/A	N/A	Sheath damage and or repair. Third party damages.

Asset Category	Function	Failure modes	Catastrophic Failure	Degraded Failures	Incipient Failures	Functional failures excluded
Non Pressurised Cable	Carry load and fault current safely and reliably, without overheating or causing damage to the environment.	Cable fault. Joint failure.	Cable Fault. Joint Fault.	N/A	N/A	Sheath damage and or repair. Third party damages.
Concrete Structures	Carries a piece of switchgear and is an integral part of the plant. This excludes plinths for plant which is designed with legs or other types of support for the operable parts of the plant and all power transformers	Loss of residual strength or loss of stability.	Failure of the structure resulting in the plant item becoming unstable, the plant tilts or in any other way cannot be operated as a result of the condition of the concrete.	Loss of section. Cracking and spilling of the concrete such that the residual strength is between 80 and 100% of current condition.	Loss of chemical structure and hence reduction in strength.	Plinths. Auxiliary structures not made of concrete. Busbar supports.

APPENDIX B
CALIBRATION – PROBABILITY OF FAILURE

B.1 Normal Expected Life

TABLE 20: NORMAL EXPECTED LIFE

Asset Register Category	Sub-division	Normal Expected Life
LV Poles	Concrete	60
	Steel	50
	Wood (water soluble copper salt treated; excluding CCA)	25
	Wood (other)	55
	Other (e.g. fibreglass)	80
LV Circuit Breaker		60
LV Pillar (ID)		60
LV Pillar (OD at Substation)		60
LV Pillar (OD not at a Substation)		60
LV Board (WM)		60
LV UGB		55
LV Board (X-type Network) (WM)		60
6.6/11kV Poles	Concrete	60
	Steel	50
	Wood (water soluble copper salt treated; excluding CCA)	25
	Wood (other)	55
	Other (e.g. fibreglass)	80
20kV Poles	Concrete	60
	Steel	50
	Wood (water soluble copper salt treated; excluding CCA)	25
	Wood (other)	55
	Other (e.g. fibreglass)	80
HV Sub Cable		60
6.6/11kV CB (GM) Primary		55*
6.6/11kV CB (GM) Secondary		55*
6.6/11kV Switch (GM)		55
6.6/11kV RMU		55
6.6/11kV X-type RMU		55
20kV CB (GM) Primary		55*
20kV CB (GM) Secondary		55*
20kV Switch (GM)		55
20kV RMU		55
6.6/11kV Transformer (GM)		60
20kV Transformer (GM)		60
33kV Pole	Concrete	60
	Steel	50
	Wood (water soluble copper salt treated; excluding CCA)	25
	Wood (other)	55
	Other (e.g. fibreglass)	80
66kV Pole	Concrete	60
	Steel	50
	Wood (water soluble copper salt treated; excluding CCA)	25
	Wood (other)	55
	Other (e.g. fibreglass)	80

Asset Register Category	Sub-division	Normal Expected Life
33kV OHL (Tower Line) Conductor	ACSR - greased	55
	ACSR - non-greased	50
	AAAC	60
	Cad Cu	50
	Cu	70
	Other	50
33kV Tower	Steelwork	80
	Foundation - Fully Encased Concrete	95
	Foundation - Earth Grillage	60
	Paint System - Galvanising	30
	Paint System - Paint	20
33kV Fittings		40
66kV OHL (Tower Line) Conductor	ACSR - greased	55
	ACSR - non-greased	50
	AAAC	60
	Cad Cu	50
	Cu	70
	Other	50
66kV Tower	Steelwork	80
	Foundation - Fully Encased Concrete	95
	Foundation - Earth Grillage	60
	Paint System - Galvanising	30
	Paint System - Paint	20
66kV Fittings		40
33kV UG Cable (Non Pressurised)	Aluminium sheath - Aluminium conductor	100
	Aluminium sheath - Copper conductor	100
	Lead sheath - Aluminium conductor	100
	Lead sheath - Copper conductor	100
33kV UG Cable (Oil)	Aluminium sheath - Aluminium conductor	75
	Aluminium sheath - Copper conductor	75
	Lead sheath - Aluminium conductor	80
	Lead sheath - Copper conductor	80
33kV UG Cable (Gas)	Aluminium sheath - Aluminium conductor	65
	Aluminium sheath - Copper conductor	70
	Lead sheath - Aluminium conductor	75
	Lead sheath - Copper conductor	75
66kV UG Cable (Non Pressurised)	Aluminium sheath - Aluminium conductor	100
	Aluminium sheath - Copper conductor	100
	Lead sheath - Aluminium conductor	100
	Lead sheath - Copper conductor	100
66kV UG Cable (Oil)	Aluminium sheath - Aluminium conductor	75
	Aluminium sheath - Copper conductor	75
	Lead sheath - Aluminium conductor	80
	Lead sheath - Copper conductor	80

Asset Register Category	Sub-division	Normal Expected Life
66kV UG Cable (Gas)	Aluminium sheath - Aluminium conductor	65
	Aluminium sheath - Copper conductor	70
	Lead sheath - Aluminium conductor	75
	Lead sheath - Copper conductor	75
EHV Sub Cable		60
33kV CB (Air Insulated Busbars)(ID)(GM)		60*
33kV CB (Air Insulated Busbars)(OD)(GM)		50*
33kV CB (Gas Insulated Busbars)(ID)(GM)		60*
33kV CB (Gas Insulated Busbars)(OD)(GM)		50
33kV Switch (GM)		55
33kV RMU		55
66kV CB (Air Insulated Busbars)(ID)(GM)		50
66kV CB (Air Insulated Busbars)(OD)(GM)		55
66kV CB (Gas Insulated Busbars)(ID)(GM)		55
66kV CB (Gas Insulated Busbars)(OD)(GM)		50
33kV Transformer (GM)	Transformer - Pre 1980	60
	Transformer - Post 1980	50
	Tapchanger	60
66kV Transformer (GM)	Transformer - Pre 1980	60
	Transformer - Post 1980	50
	Tapchanger	60
132kV OHL (Tower Line) Conductor	ACSR - greased	55
	ACSR - non-greased	50
	AAAC	60
	Cad Cu	50
	Cu	70
	Other	50
132kV Tower	Steelwork	80
	Foundation - Fully Encased Concrete	95
	Foundation - Earth Grillage	60
	Paint System - Galvanising	30
	Paint System - Paint	20
132kV Fittings		40
132kV UG Cable (Non Pressurised)	Aluminium sheath - Aluminium conductor	100
	Aluminium sheath - Copper conductor	100
	Lead sheath - Aluminium conductor	100
	Lead sheath - Copper conductor	100
132kV UG Cable (Oil)	Aluminium sheath - Aluminium conductor	75
	Aluminium sheath - Copper conductor	75
	Lead sheath - Aluminium conductor	80
	Lead sheath - Copper conductor	80
132kV UG Cable (Gas)	Aluminium sheath - Aluminium conductor	65
	Aluminium sheath - Copper conductor	70
	Lead sheath - Aluminium conductor	75
	Lead sheath - Copper conductor	75
132kV Sub Cable		60
132kV CB (Air Insulated Busbars)(ID)(GM)		60
132kV CB (Air Insulated Busbars)(OD)(GM)		50
132kV CB (Gas Insulated Busbars)(ID)(GM)		60
132kV CB (Gas Insulated Busbars)(OD)(GM)		55

Asset Register Category	Sub-division	Normal Expected Life
132kV Transformer (GM)	Transformer - Pre 1980	60
	Transformer - Post 1980	50
	Tapchanger	60

* The Normal Expected Life will be increased where applicable in accordance with Table 217 for assets that have been refurbished as specified in Appendix C.

B.2 PoF Curve Parameters

TABLE 21: POF CURVE PARAMETERS

Functional Failure Category	K-Value	C-Value	Health Score Limit
LV UGB	0.0077%	1.087	4
LV Circuit Breaker	0.0041%	1.087	4
LV Pillar (ID)	0.0046%	1.087	4
LV Pillar (OD at Substation) / LV Pillar (OD not at a Substation)			
LV Board (WM)	0.0069%	1.087	4
HV Switchgear (GM) - Primary	0.0052%	1.087	4
HV Switchgear (GM) - Distribution (GM)	0.0067%	1.087	4
EHV Switchgear (GM) (33kV & 22kV assets only)	0.0223%	1.087	4
EHV Switchgear (GM) (66kV assets only)	0.0512%	1.087	4
132kV Switchgear	0.0431%	1.087	4
HV Transformer (GM)	0.0078%	1.087	4
EHV Transformer (GM)/ 132kV Transformer (GM)	0.0454%	1.087	4
Poles	0.0285%	1.087	4
Towers	0.0545%	1.087	4
Fittings	0.0096%	1.087	4
OHL Conductor	0.0080%	1.087	4
Pressurised Cable (EHV UG Cable (Oil) and 132kV UG Cable (Oil))	2.0944%	1.087	4
Pressurised Cable (EHV UG Cable (Gas) and 132kV UG Cable (Gas))	4.5036%	1.087	4
Submarine Cables	0.0202%	1.087	4
Non Pressurised Cable	0.0658%	1.087	4

B.3 Location Factor

B.3.1 General

TABLE 22: DISTANCE FROM COAST FACTOR LOOKUP TABLE

Distance from Coast Banding	Switchgear	Transformers	Poles (Wood or Other)	Poles (Steel)	Poles (Concrete)	Towers (Structure)	Towers (Fittings)	Towers (Conductor)
≤ 1km	1.35	1.35	1	1.5	1.25	1.8	2	2
> 1km and ≤ 5km	1.1	1.1	1	1.2	1.1	1.45	1.5	1.5
> 5km and ≤ 10km	1.05	1.05	1	1.1	1.05	1.2	1.2	1.2
> 10km and ≤ 20km	1	1	1	1	1	1	1	1
>20km	0.9	0.9	1	1	1	0.85	1	1
Default	1	1	1	1	1	1	1	1

TABLE 23: ALTITUDE FACTOR LOOKUP TABLE

Altitude from Sea Level Banding	Switchgear	Transformers	Poles (Wood or Other)	Poles (Steel)	Poles (Concrete)	Towers (Structure)	Towers (Fittings)	Towers (Conductor)
≤ 100m	0.9	0.9	1	1	1	0.9	0.95	0.95
> 100m and ≤ 200m	1	1	1	1	1	1	1	1
> 200m and ≤ 300m	1.05	1.05	1	1	1	1.15	1.05	1.05
> 300m	1.1	1.1	1	1	1	1.3	1.15	1.15
Default	1	1	1	1	1	1	1	1

TABLE 24: CORROSION CATEGORY FACTOR LOOKUP TABLE

Corrosion Category Index	Switchgear	Transformers	Poles (Wood or Other)	Poles (Steel)	Poles (Concrete)	Towers (Structure)	Towers (Fittings)	Towers (Conductor)
1	0.9	0.9	1	0.9	0.9	0.75	0.95	0.95
2	0.95	0.95	1	0.95	0.95	0.9	0.95	0.95
3	1	1	1	1	1	1	1	1
4	1.1	1.1	1	1.15	1.05	1.3	1.05	1.05
5	1.25	1.25	1	1.35	1.1	1.6	1.2	1.2
Default	1	1	1	1	1	1	1	1

TABLE 25: INCREMENT CONSTANTS

Increment Constant	Switchgear	Transformers	Submarine Cables	Poles (Wood or Other)	Poles (Steel)	Poles (Concrete)	Towers (Structure)	Towers (Fittings)	Towers (Conductor)
INC	0.05	0.05	0.05	0	0	0	0	0	0

TABLE 26: DEFAULT ENVIRONMENT (INDOOR/OUTDOOR)

Asset Register Category	Default 'environment' to be assumed when deriving Location Factor
LV Poles	Outdoor
LV Circuit Breaker	Indoor
LV Pillar (ID)	Indoor
LV Pillar (OD at Substation)	Outdoor
LV Pillar (OD not at a Substation)	Outdoor
LV Board (WM)	Indoor
LV UGB	n/a
LV Board (X-type Network) (WM)	Indoor
6.6/11kV Poles	Outdoor
20kV Poles	Outdoor
HV Sub Cable	n/a
6.6/11kV CB (GM) Primary	Indoor
6.6/11kV CB (GM) Secondary	Indoor
6.6/11kV Switch (GM)	Indoor
6.6/11kV RMU	Indoor
6.6/11kV X-type RMU	Indoor
20kV CB (GM) Primary	Indoor
20kV CB (GM) Secondary	Indoor
20kV Switch (GM)	Indoor
20kV RMU	Indoor
6.6/11kV Transformer (GM)	Indoor
20kV Transformer (GM)	Indoor
33kV Pole	Outdoor
66kV Pole	Outdoor
33kV OHL (Tower Line) Conductor	Outdoor
33kV Tower	Outdoor

Asset Register Category	Default 'environment' to be assumed when deriving Location Factor
33kV Fittings	Outdoor
66kV OHL (Tower Line) Conductor	Outdoor
66kV Tower	Outdoor
66kV Fittings	Outdoor
33kV UG Cable (Non Pressurised)	n/a
33kV UG Cable (Oil)	n/a
33kV UG Cable (Gas)	n/a
66kV UG Cable (Non Pressurised)	n/a
66kV UG Cable (Oil)	n/a
66kV UG Cable (Gas)	n/a
EHV Sub Cable	n/a
33kV CB (Air Insulated Busbars)(ID)(GM)	Indoor
33kV CB (Air Insulated Busbars)(OD)(GM)	Outdoor
33kV CB (Gas Insulated Busbars)(ID)(GM)	Indoor
33kV CB (Gas Insulated Busbars)(OD)(GM)	Outdoor
33kV Switch (GM)	Indoor
33kV RMU	Indoor
66kV CB (Air Insulated Busbars)(ID)(GM)	Indoor
66kV CB (Air Insulated Busbars)(OD)(GM)	Outdoor
66kV CB (Gas Insulated Busbars)(ID)(GM)	Indoor
66kV CB (Gas Insulated Busbars)(OD)(GM)	Outdoor
33kV Transformer (GM)	Outdoor
66kV Transformer (GM)	Outdoor
132kV OHL (Tower Line) Conductor	Outdoor
132kV Tower	Outdoor
132kV Fittings	Outdoor
132kV UG Cable (Non Pressurised)	n/a
132kV UG Cable (Oil)	n/a
132kV UG Cable (Gas)	n/a
132kV Sub Cable	n/a
132kV CB (Air Insulated Busbars)(ID)(GM)	Indoor
132kV CB (Air Insulated Busbars)(OD)(GM)	Outdoor
132kV CB (Gas Insulated Busbars)(ID)(GM)	Indoor
132kV CB (Gas Insulated Busbars)(OD)(GM)	Outdoor
132kV Transformer (GM)	Outdoor

B.3.2 Submarine Cables

TABLE 27: SUBMARINE CABLE TOPOGRAPHY FACTOR

Topography	Score (Sea)	Score (Land locked)
Low Detrimental Topography	1.25	0.5
Medium Detrimental Topography	1.5	0.6
High Detrimental Topography	2.25	0.9
Very High Detrimental Topography	3	1.2
Default	1.25	0.5

TABLE 28: SUBMARINE CABLE SITUATION FACTOR

Situation	Score
Laid on bed	1
Covered	0.9
Buried	0.8
Default	1

TABLE 29: SUBMARINE CABLE WIND/WAVE FACTOR

Rating	Description	Score
1	Sheltered sea loch, Wind <200 W/m2	1
2	Wave <15kW/m, Wind 200-800 W/m2	1.2
3	Wave >15kW/m, Wind > 800 W/m2	1.4
	Default	1

TABLE 30: COMBINED WAVE & CURRENT ENERGY FACTOR

Intensity	Scoring (Sea)	Scoring (Landlocked)
Low	1.1	1
Moderate	1.25	1.15
High	1.5	1.4
Default	1.1	1

B.4 Duty Factor

TABLE 31: DUTY FACTOR LOOKUP TABLES - CABLES

Duty Factor 1 (DF1)

Maximum % Utilisation under normal operating conditions	Duty Factor (HV)	Duty Factor (EHV & 132kV)
≤ 50%	0.8	1
> 50% and ≤ 70%	0.9	1.1
> 70% and ≤ 100%	1	1.3
> 100%	1.8	2
Default	1	1

Duty Factor 2 (DF2)

Operating Voltage / Design Voltage	Duty Factor
≤ 40%	0.7
> 40% and ≤ 55%	0.8
> 55% and ≤ 70%	0.9
> 70%	1
Default	1

TABLE 32: DUTY FACTOR LOOKUP TABLE - SWITCHGEAR

Number of operations	Duty Factor
Normal/Low	1
High (e.g.: Auto-reclosers)	1.2
Default	1

TABLE 33: DUTY FACTOR LOOKUP TABLE - DISTRIBUTION TRANSFORMERS

Max % Utilisation under normal operating conditions	Duty Factor
≤ 50%	0.9
> 50% and ≤ 70%	0.95
> 70% and ≤ 100%	1
>100%	1.4
Default	1

TABLE 34: DUTY FACTOR LOOKUP TABLES - GRID & PRIMARY TRANSFORMERS

Transformer

Max % Utilisation under normal operating conditions	Duty Factor
≤ 50%	1
> 50% and ≤ 70%	1.05
> 70% and ≤ 100%	1.1
>100%	1.4
Default	1

Tapchanger

Average Number of Daily Taps	Duty Factor
≤ 7	0.9
> 7 and ≤ 14	1
> 14 and ≤ 28	1.2
> 28	1.3
Default	1

The above Transformer and Tapchanger duty factors will not be combined into a single factor, as separate Health Scores will be calculated for each element.

B.5 Observed Condition Factors

B.5.1 Overview

The following calibration tables shall be used to determine the value of each Observed Condition Input for individual assets.

The Observed Condition Inputs consist of three elements:-

i) A Condition Input Factor, which is used in the derivation of the Observed Condition Factor;
ii) a Condition Input Cap, which specifies a Health Score value that is used in the derivation of the Observed Condition Cap;
iii) a Condition Input Collar, which specifies a Health Score value that is used in the derivation of the Observed Condition Collar.

The use of Observed Condition Inputs to create the Observed Condition Modifier is described in Section 6.9.

DNOs shall map their own observed condition data to the criteria shown in these calibration tables, in order to determine the appropriate values for each of the Observed Condition Inputs. Where no data is available the default values for the Observed Condition Inputs shall be applied.

B.5.2 LV UGB

TABLE 35: OBSERVED CONDITION INPUT - LV UGB: STEEL COVER & PIT CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. Minor corrosion	1.2	10	0.5
Substantial Deterioration	e.g. Major corrosion	1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 36: OBSERVED CONDITION INPUT - LV UGB: WATER / MOISTURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
None	Dry	1	10	0.5
Present in Pit	Evidence of moisture observed in pit	1.1	10	0.5
Present in Bell Housing	Evidence of moisture observed in bell housing	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 37: OBSERVED CONDITION INPUT - LV UGB: BELL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No observed deterioration	0.9	10	0.5
Some Deterioration	e.g. Minor corrosion	1.2	10	0.5
Substantial Deterioration	e.g. Major corrosion	1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 38: OBSERVED CONDITION INPUT - LV UGB: INSULATION CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No observed deterioration	0.9	10	0.5
Some Deterioration	Chips and advanced aging	1	10	0.5
Substantial Deterioration	Evidence of flashover or damage, or degradation of insulation material	1.3	10	8
Default	No data available	1	10	0.5

TABLE 39: OBSERVED CONDITION INPUT - LV UGB: SIGNS OF HEATING

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No observed deterioration	0.9	10	0.5
Some Deterioration	Observed running higher than ambient	1	10	0.5
Substantial Deterioration	Evidence of overheating	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 40: OBSERVED CONDITION INPUT - LV UGB: PHASE BARRIERS

Condition Criteria: Phase barriers Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Yes	Phase Barriers Present	1	10	0.5
Missing	Phase Barriers Not Present (in whole or part)	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.3 LV Circuit Breaker

TABLE 41: OBSERVED CONDITION INPUT - LV CIRCUIT BREAKER: EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration:	Visual assessment gives a positive indication of asset condition. There are no obvious signs of any deterioration such as corrosion, stains or markings.	0.9	10	0.5
Superficial/minor deterioration	There is little deterioration. The asset (or a sub component) may exhibit signs of ageing, surface level scratches, moss or lichen that can be brushed off. This has no material impact on the probability of failure for the asset.	1	10	0.5
Some Deterioration	There is evidence of some degradation such as surface corrosion or minor compound leaks. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork, door-hinges heavily rusted).	1.3	10	0.5
Substantial Deterioration	The switchgear is corroded to the point that it can no longer hold its oil / SF6 insulation, one or more metalwork supports are rusted through, or the switchgear housing is damaged beyond economical repair.	1.6	10	5.5
Default	No data available	1	10	0.5

B.5.4 LV Board (WM)

TABLE 42: OBSERVED CONDITION INPUT - LV BOARD (WM): SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration:	Visual assessment gives a positive indication of asset condition. There are no obvious signs of any deterioration such as corrosion, stains or markings.	0.9	10	0.5
Superficial/minor deterioration	There is little deterioration. The asset (or a sub component) may exhibit signs of ageing, surface level scratches, moss or lichen that can be brushed off. This has no material impact on the probability of failure for the asset.	1	10	0.5
Some Deterioration	There is evidence of some degradation such as surface corrosion or minor compound leaks. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork, door-hinges heavily rusted).	1.2	10	0.5
Substantial Deterioration	The switchgear is corroded to the point that one or more metalwork supports are rusted through, or the switchgear housing is damaged beyond economical repair.	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 43: OBSERVED CONDITION INPUT - LV BOARD (WM): COMPOUND LEAKS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No leakage	1	10	0.5
Superficial/minor deterioration	Evidence of slight compound leak	1.1	10	0.5
Substantial deterioration	Significant compound leak or multiple compound leaks on the same board.	1.3	10	5.5
Default	No data available	1	10	0.5

TABLE 44: OBSERVED CONDITION INPUT - LV BOARD (WM): SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some deterioration	Minor corrosion (e.g. light rust) or evidence of a minor mechanism defect.	1.2	10	3.0
Substantial deterioration	Evidence of significant corrosion, missing, defective or damaged internal insulation (e.g. evidence of severe discharge activity or breakdown of insulation) or a severe mechanism defect that affects the operation of the asset.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 45: OBSERVED CONDITION INPUT - LV BOARD (WM): INSULATION CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Satisfactory	No observed deterioration	0.9	10	0.5
Some Deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Substantial Deterioration	Degradation of insulation material	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 46: OBSERVED CONDITION INPUT - LV BOARD (WM): SIGNS OF HEATING

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No obvious degradation	1	10	0.5
Minor Deterioration	Observed running higher than ambient	1.2	10	0.5
Major Deterioration	Evidence of overheating	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 47: OBSERVED CONDITION INPUT - LV BOARD (WM): PHASE BARRIERS

Condition Criteria: Phase barriers Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Yes	Phase Barriers Present	1	10	0.5
Missing	Phase Barriers Not Present (in whole or part)	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.5 LV Pillar

TABLE 48: OBSERVED CONDITION INPUT - LV PILLAR: SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration:	Visual assessment gives a positive indication of asset condition. There are no obvious signs of any deterioration such as corrosion, stains or markings.	0.9	10	0.5
Superficial/minor deterioration	There is little deterioration The asset (or a sub component) may exhibit signs of ageing, surface level scratches, moss or lichen that can be brushed off. This has no material impact on the probability of failure for the asset.	1	10	0.5
Some Deterioration	There is evidence of some degradation such as surface corrosion or minor compound leaks. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork, door-hinges heavily rusted).	1.2	10	0.5
Substantial Deterioration	The switchgear is corroded to the point that one or more metalwork supports are rusted through, or the switchgear housing is damaged beyond economical repair.	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 49: OBSERVED CONDITION INPUT - LV PILLAR: COMPOUND LEAKS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No leakage	1	10	0.5
Superficial/minor deterioration	Evidence of slight compound leak	1.1	10	0.5
Substantial deterioration	Significant compound leak or multiple compound leaks on the same pillar.	1.3	10	5.5
Default	No data available	1	10	0.5

TABLE 50: OBSERVED CONDITION INPUT - LV PILLAR: SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	Minor corrosion (e.g. light rust) or evidence of a minor mechanism defect.	1.2	10	3.0
Substantial Deterioration	Evidence of significant corrosion, missing, defective or damaged internal insulation (e.g. evidence of severe discharge activity or breakdown of insulation) or a severe mechanism defect that affects the operation of the asset.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 51: OBSERVED CONDITION INPUT - LV PILLAR: INSULATION CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Satisfactory	No observed deterioration	0.9	10	0.5
Some Deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Substantial Deterioration	Degradation of insulation material	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 52: OBSERVED CONDITION INPUT - LV PILLAR: SIGNS OF HEATING

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No obvious degradation	1	10	0.5
Minor Deterioration	Observed running higher than ambient	1.2	10	0.5
Major Deterioration	Evidence of overheating	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 53: OBSERVED CONDITION INPUT - LV PILLAR: PHASE BARRIERS

Condition Criteria: Phase barriers Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Yes	Phase Barriers Present	1	10	0.5
Missing	Phase Barriers Not Present (in whole or part)	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.6 HV Switchgear (GM) - Distribution

TABLE 54: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration:	Visual assessment gives a positive indication of asset condition. There are no obvious signs of any deterioration such as corrosion, stains or markings.	0.9	10	0.5
Superficial/minor deterioration	There is little deterioration. The asset (or a sub component) may exhibit signs of ageing, surface level scratches, moss or lichen that can be brushed off. This has no material impact on the probability of failure for the asset.	1	10	0.5
Some Deterioration	There is evidence of some degradation such as surface corrosion or minor compound leaks. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork, door-hinges heavily rusted).	1.2	10	3.0
Substantial Deterioration	The switchgear is corroded to the point that it can no longer hold its oil / SF6 insulation, one or more metalwork supports are rusted through, or the switchgear housing is damaged beyond economical repair.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 55: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: OIL LEAKS / GAS PRESSURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	Oil: No Oil appears to be actively leaking from the component in question. This may include assets with minor stains or marks Gas: Gas pressure reading is within the expected limit	0.9	10	0.5
Superficial/minor deterioration	Oil: There is evidence of a small leak, but this is limited to staining of the asset or the ground around the asset AND oil still visible in the sight glass where fitted. Repairs / intervention to the asset (or a sub component) is not expected to be required between now and the next planned maintenance Gas: Not used	1	10	0.5
Some Deterioration	Oil: There is evidence of a small active oil leak from the switchgear e.g. droplets or weeping beneath the fixed portion. Minor maintenance or refurbishment activities (as a minimum) are required to address the identified issue(s) Gas: Gas pressure outside of acceptable range	1.1	10	3.0
Substantial Deterioration	Oil: There is evidence of a significant oil leak from the switchgear e.g. pool of oil under/around the equipment, the switchgear may be draining or completely drained of oil and / or compound. Gas: Severe unrepairable leak or equipment requiring repeated top ups.	1.3	10	8.0
Default	No data available	1	10	0.5

TABLE 56: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: THERMOGRAPHIC ASSESSMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 57: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	Minor corrosion (e.g. light rust) or evidence of a minor mechanism defect.	1.2	10	3.0
Substantial Deterioration	Evidence of significant corrosion, missing, defective or damaged internal insulation (e.g. evidence of severe discharge activity or breakdown of insulation) or a severe mechanism defect that affects the operation of the asset.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 58: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: INDOOR ENVIRONMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Better than Expected	Air conditioned	0.9	10	0.5
As Expected	This is an environment which is typified as dry and has a degree of background heating or dehumidification which maintains this year round.	1	10	0.5
Deteriorated Environment	Heating or dehumidification faulty; room temperature is hotter than recommended by environmental policy; condensation evident in switch room etc.	1.3	10	0.5
Severely Deteriorated Environment	The substation is showing major signs of dampness such as definite water marks around the building, significant amount of flaking paint and/or mould growth. No environmental controls (such as heating or dehumidification) are installed, or the installed environmental controls are not functioning adequately; room temperature is excessively hot; roof or structure permits water ingress; water stands in trenches or free water is observed in the switch room.	1.5	10	0.5
Default	No data available	1	10	0.5

TABLE 59: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: CABLE BOXES CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration*	There are no signs of any deterioration such as corrosion, stains, markings, compound leaks, discharge etc.	1	10	0.5
Superficial / minor deterioration*	The cable box may exhibit minor exterior stains or marks (e.g. surface level scratches, moss or lichen that can be brushed off), but no damage or corrosion should be evident. No evidence of compound leaks, discharge, signs of heating, or deterioration of insulation.	1	10	0.5
Some Deterioration	Minor corrosion (e.g. surface corrosion spots) or deterioration (e.g. minor breakthrough of paintwork but no loss of galvanising).	1.1	10	0.5
Substantial Deterioration	Evidence of significant corrosion and perforation (e.g. holes). Severe breakthrough of paintwork with some loss of galvanising. Major compound leaks. Evidence of discharge, signs of heating, deterioration/ damage of insulation.	1.3	10	0.5
Default	No data available	1	10	0.5

** - note: as both the 'No Deterioration' and 'Superficial/minor deterioration' Condition Criteria for this Condition Input are treated in the same way by the Methodology, the categorisations for these two Condition Criteria may be combined in individual implementations of the Methodology.*

B.5.7 HV Switchgear (GM) - Primary

TABLE 60: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration:	Visual assessment gives a positive indication of asset condition. There are no obvious signs of any deterioration such as corrosion, stains or markings.	0.9	10	0.5
Superficial/minor deterioration	There is little deterioration. The asset (or a sub component) may exhibit signs of ageing, surface level scratches, moss or lichen that can be brushed off. This has no material impact on the probability of failure for the asset.	1	10	0.5
Some Deterioration	There is evidence of some degradation such as surface corrosion or minor compound leaks. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork, door-hinges heavily rusted).	1.2	10	3.0
Substantial Deterioration	The switchgear is corroded to the point that it can no longer hold its oil / SF6 insulation, one or more metalwork supports are rusted through, or the switchgear housing is damaged beyond economical repair.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 61: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: OIL LEAKS / GAS PRESSURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	Oil: No Oil appears to be actively leaking from the component in question. This may include assets with minor stains or marks Gas: Gas pressure reading is within the expected limit	0.9	10	0.5
Superficial/minor deterioration	Oil: There is evidence of a small leak, but this is limited to staining of the asset or the ground around the asset AND oil still visible in the sight glass where fitted. Repairs / intervention to the asset (or a sub component) is not expected to be required between now and the next planned maintenance Gas: Not used	1	10	0.5
Some Deterioration	Oil: There is evidence of a small active oil leak from the switchgear e.g. droplets or weeping beneath the fixed portion. Minor maintenance or refurbishment activities (as a minimum) are required to address the identified issue(s) Gas: Gas pressure outside of acceptable range	1.1	10	3.0
Substantial Deterioration	Oil: There is evidence of a significant oil leak from the switchgear e.g. pool of oil under/around the equipment, the switchgear may be draining or completely drained of oil and / or compound. Gas: Severe unrepairable leak or equipment requiring repeated top ups.	1.3	10	8.0
Default	No data available	1	10	0.5

TABLE 62: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: THERMOGRAPHIC ASSESSMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above ambient	Above ambient temperature	1	10	0.5
Substantially above ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 63: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	Minor corrosion (e.g. light rust) or evidence of a minor mechanism defect.	1.2	10	3.0
Substantial Deterioration	Evidence of significant corrosion, missing, defective or damaged internal insulation (e.g. evidence of severe discharge activity or breakdown of insulation) or a severe mechanism defect that affects the operation of the asset.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 64: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: INDOOR ENVIRONMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Better than expected	Air conditioned	0.9	10	0.5
As Expected	This is an environment which is typified as dry and has a degree of background heating or dehumidification which maintains this year round.	1	10	0.5
Deteriorated Environment	Heating or dehumidification faulty; room temperature is hotter than recommended by environmental policy; condensation evident in switch room etc.	1.3	10	0.5
Severely Deteriorated Environment	The substation is showing major signs of dampness such as definite water marks around the building, significant amount of flaking paint and/or mould growth. No environmental controls (such as heating or dehumidification) are installed, or the installed environmental controls are not functioning adequately; room temperature is excessively hot; roof or structure permits water ingress; water stands in trenches or free water is observed in the switch room.	1.5	10	0.5
Default	No data available	1	10	0.5

TABLE 65: OBSERVED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: CABLE BOXES CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration*	There are no signs of any deterioration such as corrosion, stains, markings, compound leaks, discharge etc.	1	10	0.5
Superficial / minor deterioration*	The cable box may exhibit minor exterior stains or marks (e.g. surface level scratches, moss or lichen that can be brushed off), but no damage or corrosion should be evident. No evidence of compound leaks, discharge, signs of heating, or deterioration of insulation.	1	10	0.5
Some Deterioration	Minor corrosion (e.g. surface corrosion spots) or deterioration (e.g. minor breakthrough of paintwork but no loss of galvanising).	1.1	10	0.5
Substantial Deterioration	Evidence of significant corrosion and perforation (e.g. holes). Severe breakthrough of paintwork with some loss of galvanising. Major compound leaks. Evidence of discharge, signs of heating, deterioration/ damage of insulation.	1.3	10	0.5
Default	No data available	1	10	0.5

** - note: as both the 'No Deterioration' and 'Superficial/minor deterioration' Condition Criteria for this Condition Input are treated in the same way by the Methodology, the categorisations for these two Condition Criteria may be combined in individual implementations of the Methodology.*

B.5.8 EHV Switchgear (GM)

TABLE 66: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration:	Visual assessment gives a positive indication of asset condition. There are no obvious signs of any deterioration such as corrosion, stains or markings.	0.9	10	0.5
Superficial/minor deterioration	There is little deterioration. The asset (or a sub component) may exhibit signs of ageing, surface level scratches, moss or lichen that can be brushed off. This has no material impact on the probability of failure for the asset.	1	10	0.5
Some Deterioration	There is evidence of some degradation such as surface corrosion or minor compound leaks. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork, door-hinges heavily rusted).	1.2	10	3.0
Substantial Deterioration	The switchgear is corroded to the point that it can no longer hold its oil / SF6 insulation, one or more metalwork supports are rusted through, or the switchgear housing is damaged beyond economical repair.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 67: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): OIL LEAKS / GAS PRESSURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	Oil: No Oil appears to be actively leaking from the component in question. This may include assets with minor stains or marks Gas: Gas pressure reading is within the expected limit	0.9	10	0.5
Superficial/minor deterioration	Oil: There is evidence of a small leak, but this is limited to staining of the asset or the ground around the asset AND oil still visible in the sight glass where fitted. Repairs / intervention to the asset (or a sub component) is not expected to be required between now and the next planned maintenance Gas: Not used	1	10	0.5
Some Deterioration	Oil: There is evidence of a small active oil leak from the switchgear e.g. droplets or weeping beneath the fixed portion. Minor maintenance or refurbishment activities (as a minimum) are required to address the identified issue(s) Gas: Gas pressure outside of acceptable range	1.1	10	3.0
Substantial Deterioration	Oil: There is evidence of a significant oil leak from the switchgear e.g. pool of oil under/around the equipment, the switchgear may be draining or completely drained of oil and / or compound. Gas: Severe unrepairable leak or equipment requiring repeated top ups.	1.3	10	8.0
Default	No data available	1	10	0.5

TABLE 68: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): THERMOGRAPHIC ASSESSMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 69: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	Minor corrosion (e.g. light rust) or evidence of a minor mechanism defect.	1.2	10	3.0
Substantial Deterioration	Evidence of significant corrosion, missing, defective or damaged internal insulation (e.g. evidence of severe discharge activity or breakdown of insulation) or a severe mechanism defect that affects the operation of the asset.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 70: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): INDOOR ENVIRONMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Better than Expected	Air conditioned	0.9	10	0.5
As Expected	This is an environment which is typified as dry and has a degree of background heating or dehumidification which maintains this year round.	1	10	0.5
Deteriorated Environment	Heating or dehumidification faulty; room temperature is hotter than recommended by environmental policy; condensation evident in switch room etc.	1.3	10	0.5
Severely Deteriorated Environment	The substation is showing major signs of dampness such as definite water marks around the building, significant amount of flaking paint and/or mould growth. No environmental controls (such as heating or dehumidification) are installed, or the installed environmental controls are not functioning adequately; room temperature is excessively hot; roof or structure permits water ingress; water stands in trenches or free water is observed in the switch room.	1.5	10	0.5
Default	No data available	1	10	0.5

TABLE 71: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): SUPPORT STRUCTURES

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	Visual assessment gives a positive indication of asset condition. There are no obvious signs of any deterioration such as corrosion or cracks.	0.9	10	0.5
Superficial/minor deterioration	Concrete Structures: Surface Deterioration Metal Structures: Minor localised surface corrosion	1	10	0.5
Some Deterioration	Concrete Structures: Evidence of previous concrete repairs, repairs have begun to fail in places. This may include minor cracks and loss of section. Metal structures: some surface level corrosion.	1.3	10	0.5
Substantial Deterioration	The support structure is corroded or damaged to the point that it can no longer fulfil its mechanical load carrying capacity. This may include: Concrete structures: extensive cracking, areas of concrete spalled exposing reinforcement causing corrosion. Metal structures: evidence of widespread or significant corrosion (e.g. perforation, holes in steelwork) or major physical damage.	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 72: OBSERVED CONDITION INPUT - EHV SWITCHGEAR (GM): CABLE BOXES CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration*	There are no signs of any deterioration such as corrosion, stains, markings, compound leaks, discharge etc.	1	10	0.5
Superficial / minor deterioration*	The cable box may exhibit minor exterior stains or marks (e.g. surface level scratches, moss or lichen that can be brushed off), but no damage or corrosion should be evident. No evidence of compound leaks, discharge, signs of heating, or deterioration of insulation.	1	10	0.5
Some Deterioration	Minor corrosion (e.g. surface corrosion spots) or deterioration (e.g. minor breakthrough of paintwork but no loss of galvanising).	1.1	10	0.5
Substantial Deterioration	Evidence of significant corrosion and perforation (e.g. holes). Severe breakthrough of paintwork with some loss of galvanising. Major compound leaks. Evidence of discharge, signs of heating, deterioration/ damage of insulation.	1.3	10	0.5
Default	No data available	1	10	0.5

** - note: as both the 'No Deterioration' and 'Superficial/minor deterioration' Condition Criteria for this Condition Input are treated in the same way by the Methodology, the categorisations for these two Condition Criteria may be combined in individual implementations of the Methodology.*

B.5.9 132kV Switchgear (GM)

TABLE 73: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): SWITCHGEAR EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration:	Visual assessment gives a positive indication of asset condition. There are no obvious signs of any deterioration such as corrosion, stains or markings.	0.9	10	0.5
Superficial/minor deterioration	There is little deterioration. The asset (or a sub component) may exhibit signs of ageing, surface level scratches, moss or lichen that can be brushed off. This has no material impact on the probability of failure for the asset.	1	10	0.5
Some Deterioration	There is evidence of some degradation such as surface corrosion or minor compound leaks. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork, door-hinges heavily rusted).	1.2	10	3.0
Substantial Deterioration	The switchgear is corroded to the point that it can no longer hold its oil / SF6 insulation, one or more metalwork supports are rusted through, or the switchgear housing is damaged beyond economical repair.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 74: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): OIL LEAKS / GAS PRESSURE

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	Oil: No Oil appears to be actively leaking from the component in question. This may include assets with minor stains or marks Gas: Gas pressure reading is within the expected limit	0.9	10	0.5
Superficial/minor deterioration	Oil: There is evidence of a small leak, but this is limited to staining of the asset or the ground around the asset AND oil still visible in the sight glass where fitted. Repairs / intervention to the asset (or a sub component) is not expected to be required between now and the next planned maintenance Gas: Not used	1	10	0.5
Some Deterioration	Oil: There is evidence of a small active oil leak from the switchgear e.g. droplets or weeping beneath the fixed portion. Minor maintenance or refurbishment activities (as a minimum) are required to address the identified issue(s) Gas: Gas pressure outside of acceptable range	1.1	10	3.0
Substantial Deterioration	Oil: There is evidence of a significant oil leak from the switchgear e.g. pool of oil under/around the equipment, the switchgear may be draining or completely drained of oil and / or compound. Gas: Severe unrepairable leak or equipment requiring repeated top ups.	1.3	10	8.0
Default	No data available	1	10	0.5

TABLE 75: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): THERMOGRAPHIC ASSESSMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 76: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): SWITCHGEAR INTERNAL CONDITION & OPERATION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	Minor corrosion (e.g. light rust) or evidence of a minor mechanism defect.	1.2	10	3.0
Substantial Deterioration	Evidence of significant corrosion, missing, defective or damaged internal insulation (e.g. evidence of severe discharge activity or breakdown of insulation) or a severe mechanism defect that affects the operation of the asset.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 77: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): INDOOR ENVIRONMENT

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Better than Expected	Air conditioned	0.9	10	0.5
As Expected	This is an environment which is typified as dry and has a degree of background heating or dehumidification which maintains this year round.	1	10	0.5
Deteriorated Environment	Heating or dehumidification faulty; room temperature is hotter than recommended by environmental policy; condensation evident in switch room etc.	1.3	10	0.5
Severely Deteriorated Environment	The substation is showing major signs of dampness such as definite water marks around the building, significant amount of flaking paint and/or mould growth. No environmental controls (such as heating or dehumidification) are installed, or the installed environmental controls are not functioning adequately; room temperature is excessively hot; roof or structure permits water ingress; water stands in trenches or free water is observed in the switch room.	1.5	10	0.5
Default	No data available	1	10	0.5

TABLE 78: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): SUPPORT STRUCTURES

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	Visual assessment gives a positive indication of asset condition. There are no obvious signs of any deterioration such as corrosion or cracks.	0.9	10	0.5
Superficial/minor deterioration	Concrete Structures: Surface Deterioration Metal Structures: Minor localised surface corrosion	1	10	0.5
Some Deterioration	Concrete Structures: Evidence of previous concrete repairs, repairs have begun to fail in places. This may include minor cracks and loss of section. Metal structures: some surface level corrosion.	1.3	10	0.5

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Substantial Deterioration	The support structure is corroded or damaged to the point that it can no longer fulfil its mechanical load carrying capacity. This may include: Concrete structures: extensive cracking, areas of concrete spalled exposing reinforcement causing corrosion. Metal structures: evidence of widespread or significant corrosion (e.g. perforation, holes in steelwork) or major physical damage.	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 79: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): AIR SYSTEMS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	Minor surface corrosion observed on observable pipe work	1	10	0.5
Some Deterioration	Minor Air Losses - System runs excessively to maintain pressure	1.3	10	0.5
Substantial Deterioration	Major Air Losses - Loss of pressure pipe section observed. Air leaks can be found by inspection; Certification notes defects. Etc.	1.5	10	0.5
Default	No data available	1	10	0.5

TABLE 80: OBSERVED CONDITION INPUT - 132KV SWITCHGEAR (GM): CABLE BOXES CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration*	There are no signs of any deterioration such as corrosion, stains, markings, compound leaks, discharge etc.	1	10	0.5
Superficial / minor deterioration*	The cable box may exhibit minor exterior stains or marks (e.g. surface level scratches, moss or lichen that can be brushed off), but no damage or corrosion should be evident. No evidence of compound leaks, discharge, signs of heating, or deterioration of insulation.	1	10	0.5
Some Deterioration	Minor corrosion (e.g. surface corrosion spots) or deterioration (e.g. minor breakthrough of paintwork but no loss of galvanising).	1.1	10	0.5
Substantial Deterioration	Evidence of significant corrosion and perforation (e.g. holes). Severe breakthrough of paintwork with some loss of galvanising. Major compound leaks. Evidence of discharge, signs of heating, deterioration/ damage of insulation.	1.3	10	0.5
Default	No data available	1	10	0.5

** - note: as both the 'No Deterioration' and 'Superficial/minor deterioration' Condition Criteria for this Condition Input are treated in the same way by the Methodology, the categorisations for these two Condition Criteria may be combined in individual implementations of the Methodology.*

B.5.10 HV Transformer (GM)

TABLE 81: OBSERVED CONDITION INPUT - HV TRANSFORMER (GM): TRANSFORMER EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	Condition as new	0.9	10	0.5
Superficial/minor deterioration	The transformer may exhibit signs of ageing or marks (e.g. surface level scratches, moss or lichen that can be brushed off). This has no material impact on the probability of failure for the asset.	1	10	0.5
Slight deterioration	Minor localised surface corrosion. There may be evidence of a small leak, but it does not present a significant impact to the overall probability of failure for the asset, for example: - There is a small active leak from a sub component but this can be addressed through intervention of the sub component - A small inactive leak which is limited to staining of the asset or the ground around the asset.	1.1	10	0.5
Some Deterioration	The asset shows a level of deterioration such as surface corrosion spots. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork); and/or there is evidence of a small active oil leak (e.g. droplets or weeping).	1.25	10	3.0
Substantial Deterioration	There is evidence of major corrosion or a significant active oil leak (e.g. pools of oil collecting on the ground or plinth).	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 82: OBSERVED CONDITION INPUT - HV TRANSFORMER (GM): CABLE BOXES CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration*	There are no signs of any deterioration such as corrosion, stains, markings, compound leaks, discharge etc.	1	10	0.5
Superficial / minor deterioration*	The cable box may exhibit minor exterior stains or marks (e.g. surface level scratches, moss or lichen that can be brushed off), but no damage or corrosion should be evident. No evidence of compound leaks, discharge, signs of heating, or deterioration of insulation.	1	10	0.5
Some Deterioration	Minor corrosion (e.g. surface corrosion spots) or deterioration (e.g. minor breakthrough of paintwork but no loss of galvanising).	1.1	10	0.5
Substantial Deterioration	Evidence of significant corrosion and perforation (e.g. holes). Severe breakthrough of paintwork with some loss of galvanising. Major compound leaks. Evidence of discharge, signs of heating, deterioration/ damage of insulation.	1.3	10	0.5
Default	No data available	1	10	0.5

** - note: as both the 'No Deterioration' and 'Superficial/minor deterioration' Condition Criteria for this Condition Input are treated in the same way by the Methodology, the categorisations for these two Condition Criteria may be combined in individual implementations of the Methodology.*

B.5.11 EHV Transformer (GM) (Main Transformer component)

TABLE 83: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): MAIN TANK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The transformer may exhibit signs of ageing or marks (e.g. surface level scratches, moss or lichen that can be brushed off). This has no material impact on the probability of failure for the asset. There may be evidence of a small leak, but it does not present a significant impact to the overall probability of failure for the asset, for example: - There is a small active leak from a sub component (e.g. a pressure relief device) but this can be addressed through intervention of the sub component. - The leak this is limited to staining of the asset or the ground around the asset.	1	10	0.5
Some Deterioration	The asset shows a level of deterioration such as surface corrosion spots or minor oil leaks. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork); and/or there is evidence of a small active oil leak (e.g. droplets or weeping).	1.4	10	4.0
Substantial Deterioration	There is evidence of major corrosion or a significant active and unrepairable oil leak (e.g. pools of oil collecting on the ground or plinth).	1.8	10	8.0
Default	No data available	1	10	0.5

TABLE 84: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): COOLERS / RADIATOR CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset (or a sub component) may exhibit signs of ageing, minor stains or marks (e.g. surface level scratches, moss or lichen that can be brushed off). This has no material impact on the probability of failure for the asset.	1	10	0.5
Some Deterioration	Localised areas of surface corrosion or evidence of oil leaks not associated with the transformer fins (e.g. manifolds and associated pipework, flanges, couplings, valves)	1.2	10	0.5
Substantial Deterioration	Widespread corrosion, loss of cross-sectional area or thinning or evidence of oil leakage from the fins.	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 85: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): BUSHINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	Minor corrosion or evidence of a historic oil leak (e.g. stains) or minor damage (e.g. small chips or cracks). Bushings with high levels of pollution with associated evidence of localised discharge or tracking.	1.2	10	0.5

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Substantial Deterioration	Visible cracks, broken sheds, damage, surface degradation, widespread/significant discharge activity and/or active oil leak (e.g. droplets, pools of oil).	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 86: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): KIOSK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset component exhibits some deterioration but is fit for continued service. There is no or little obvious signs of corrosion.	1	10	0.5
Some Deterioration	The component asset shows a level of deterioration such as surface corrosion spots. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork).	1.1	10	0.5
Substantial Deterioration	There is evidence of major corrosion or damage affecting the structural integrity.	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 87: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): CABLE BOXES CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration*	There are no signs of any deterioration such as corrosion, stains, markings, compound leaks, discharge etc.	1	10	0.5
Superficial / minor deterioration*	The cable box may exhibit minor exterior stains or marks (e.g. surface level scratches, moss or lichen that can be brushed off), but no damage or corrosion should be evident. No evidence of compound leaks, discharge, signs of heating, or deterioration of insulation.	1	10	0.5
Some Deterioration	Minor corrosion (e.g. surface corrosion spots) or deterioration (e.g. minor breakthrough of paintwork but no loss of galvanising).	1.1	10	0.5
Substantial Deterioration	Evidence of significant corrosion and perforation (e.g. holes). Severe breakthrough of paintwork with some loss of galvanising. Major compound leaks. Evidence of discharge, signs of heating, deterioration/ damage of insulation.	1.3	10	0.5
Default	No data available	1	10	0.5

** - note: as both the 'No Deterioration' and 'Superficial/minor deterioration' Condition Criteria for this Condition Input are treated in the same way by the Methodology, the categorisations for these two Condition Criteria may be combined in individual implementations of the Methodology.*

B.5.12 EHV Transformer (GM) (Tapchanger component)

TABLE 88: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): TAPCHANGER EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.4	10	4.0
Substantial Deterioration	e.g. major corrosion or evidence of significant oil leakage	1.8	10	8.0
Default	No data available	1	10	0.5

TABLE 89: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): INTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	3.0
Substantial Deterioration	e.g. observed or potential mechanism defect, internal insulation, etc.	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 90: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): DRIVE MECHANISM CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear to components	1.2	10	0.5
Substantial Deterioration	e.g. major corrosion or excessive wear in component and bearings	1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 91: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): CONDITION OF SELECTOR & DIVERTER CONTACTS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.95	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear	1.1	10	0.5
Substantial Deterioration	e.g. major corrosion or excessive wear in component and bearings	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 92: OBSERVED CONDITION INPUT - EHV TRANSFORMER (GM): CONDITION OF SELECTOR & DIVERTER BRAIDS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.95	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear	1.05	10	0.5
Substantial Deterioration	e.g. major corrosion or fraying of braids	1.1	10	0.5
Default	No data available	1	10	0.5

B.5.13 132kV Transformer (GM) (Main Transformer component)

TABLE 93: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): MAIN TANK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The transformer may exhibit signs of ageing or marks (e.g. surface level scratches, moss or lichen that can be brushed off). This has no material impact on the probability of failure for the asset. There may be evidence of a small leak, but it does not present a significant impact to the overall probability of failure for the asset, for example: - There is a small active leak from a sub component (e.g. a pressure relief device) but this can be addressed through intervention of the sub component. The leak this is limited to staining of the asset or the ground around the asset.	1	10	0.5
Some Deterioration	The asset shows a level of deterioration such as surface corrosion spots or minor oil leaks. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork); and/or there is evidence of a small active oil leak (e.g. droplets or weeping).	1.4	10	4.0
Substantial Deterioration	There is evidence of major corrosion or a significant active and unrepairable oil leak (e.g. pools of oil collecting on the ground or plinth).	1.8	10	8.0
Default	No data available	1	10	0.5

TABLE 94: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): COOLERS / RADIATOR CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset (or a sub component) may exhibit signs of ageing, minor stains or marks (e.g. surface level scratches, moss or lichen that can be brushed off). This has no material impact on the probability of failure for the asset.	1	10	0.5
Some Deterioration	Localised areas of surface corrosion or evidence of oil leaks not associated with the transformer fins (e.g. manifolds and associated pipework, flanges, couplings, valves)	1.2	10	0.5
Substantial Deterioration	Widespread corrosion, loss of cross-sectional area or thinning or evidence of oil leakage from the fins.	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 95: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): BUSHINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	Minor corrosion or evidence of a historic oil leak (e.g. stains) or minor damage (e.g. small chips or cracks). Bushings with high levels of pollution with associated evidence of localised discharge or tracking.	1.2	10	0.5
Substantial Deterioration	Visible cracks, broken sheds, damage, surface degradation, widespread/significant discharge activity and/or active oil leak (e.g. droplets, pools of oil).	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 96: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): KIOSK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset component exhibits some deterioration but is fit for continued service. There is no or little obvious signs of corrosion.	1	10	0.5
Some Deterioration	The component asset shows a level of deterioration such as surface corrosion spots. The level of degradation may affect the operation of the asset if left untended (e.g. large patches of rust on the metalwork).	1.1	10	0.5
Substantial Deterioration	There is evidence of major corrosion or damage affecting the structural integrity.	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 97: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): CABLE BOXES CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No Deterioration*	There are no signs of any deterioration such as corrosion, stains, markings, compound leaks, discharge etc.	1	10	0.5
Superficial / minor deterioration*	The cable box may exhibit minor exterior stains or marks (e.g. surface level scratches, moss or lichen that can be brushed off), but no damage or corrosion should be evident. No evidence of compound leaks, discharge, signs of heating, or deterioration of insulation.	1	10	0.5
Some Deterioration	Minor corrosion (e.g. surface corrosion spots) or deterioration (e.g. minor breakthrough of paintwork but no loss of galvanising).	1.1	10	0.5
Substantial Deterioration	Evidence of significant corrosion and perforation (e.g. holes). Severe breakthrough of paintwork with some loss of galvanising. Major compound leaks. Evidence of discharge, signs of heating, deterioration/ damage of insulation.	1.3	10	0.5
Default	No data available	1	10	0.5

** - note: as both the 'No Deterioration' and 'Superficial/minor deterioration' Condition Criteria for this Condition Input are treated in the same way by the Methodology, the categorisations for these two Condition Criteria may be combined in individual implementations of the Methodology.*

B.5.14 132kV Transformer (GM) (Tapchanger component)

TABLE 98: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): TAPCHANGER EXTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.4	10	4.0
Substantial Deterioration	e.g. major corrosion or evidence of significant oil leakage	1.8	10	8.0
Default	No data available	1	10	0.5

TABLE 99: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): INTERNAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or evidence of low level oil leaks (If appropriate)	1.2	10	3.0
Substantial Deterioration	e.g. observed or potential mechanism defect, internal insulation, etc+	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 100: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): DRIVE MECHANISM CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear to components	1.2	10	0.5
Substantial Deterioration	e.g. major corrosion or excessive wear in component and bearings	1.4	10	0.5
Default	No data available	1	10	0.5

TABLE 101: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): CONDITION OF SELECTOR & DIVERTER CONTACTS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.95	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear	1.1	10	0.5
Substantial Deterioration	e.g. major corrosion or excessive wear in component and bearings	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 102: OBSERVED CONDITION INPUT - 132KV TRANSFORMER (GM): CONDITION OF SELECTOR & DIVERTER BRAIDS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.95	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	10	0.5
Some Deterioration	e.g. minor corrosion or wear	1.05	10	0.5
Substantial Deterioration	e.g. major corrosion or fraying of braids	1.1	10	0.5
Default	No data available	1	10	0.5

B.5.15 EHV Cable (Oil)

TABLE 103: OBSERVED CONDITION INPUT - EHV CABLE (OIL): PRESENCE OF CRYSTALLINE LEAD

Condition Criteria: Lead Crystallisation Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	Applicable to cables in the Lead sheath sub-division only: No lead crystallisation has been identified in the sheath of the cable or any other lead sheath cable within the same hydraulic section, on any occasion where the lead sheath of the cable has been exposed (e.g. during fault repair, leak location, construction works etc.).	1	10	0.5
Yes	Applicable to cables in the Lead sheath sub-division only: Evidence of lead crystallisation has been identified in the sheath of the cable or any other lead sheath cable within the same hydraulic section, on one or more occasions where the lead sheath of the cable has been exposed (e.g. during fault repair, leak location, construction works etc.).	1.8	10	8
Not applicable	This condition input is not applicable because the exposed cable within the hydraulic section is in the Aluminium sheath sub-division or the Lead sheath cable section has not been exposed.	1	10	0.5
Default	No data available	1	10	0.5

*This condition is only collected by exception, i.e. when the cable section is uncovered for fault repair, leak detection, construction works etc.

B.5.16 EHV Cable (Gas)

TABLE 104: OBSERVED CONDITION INPUT - EHV CABLE (GAS): PRESENCE OF CRYSTALLINE LEAD

Condition Criteria: Lead Crystallisation Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	Applicable to cables in the Lead sheath sub-division only: No lead crystallisation has been identified in the sheath of the cable or any other lead sheath cable within the same pneumatic section, on any occasion where the lead sheath of the cable has been exposed (e.g. during fault repair, leak location, construction works etc.).	1	10	0.5
Yes	Applicable to cables in the Lead sheath sub-division only: Evidence of lead crystallisation has been identified in the sheath of the cable or any other lead sheath cable within the same pneumatic section, on one or more occasions where the lead sheath of the cable has been exposed (e.g. during fault repair, leak location, construction works etc.).	1.8	10	8
Not applicable	This condition input is not applicable because the exposed cable within the pneumatic section is in the Aluminium sheath sub-division or the Lead sheath cable section has not been exposed.	1	10	0.5
Default	No data available	1	10	0.5

**This condition is only collected by exception, i.e. when the cable section is uncovered for fault repair, leak detection, construction works etc.*

B.5.17 132kV Cable (Oil)

TABLE 105: OBSERVED CONDITION INPUT - 132KV CABLE (OIL): PRESENCE OF CRYSTALLINE LEAD

Condition Criteria: Lead Crystallisation Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	Applicable to cables in the Lead sheath sub-division only: No lead crystallisation has been identified in the sheath of the cable or any other lead sheath cable within the same hydraulic section, on any occasion where the lead sheath of the cable has been exposed (e.g. during fault repair, leak location, construction works etc.).	1	10	0.5
Yes	Applicable to cables in the Lead sheath sub-division only: Evidence of lead crystallisation has been identified in the sheath of the cable or any other lead sheath cable within the same hydraulic section, on one or more occasions where the lead sheath of the cable has been exposed (e.g. during fault repair, leak location, construction works etc.).	1.8	10	8
Not applicable	This condition input is not applicable because the exposed cable within the hydraulic section is in the Aluminium sheath sub-division or the Lead sheath cable section has not been exposed.	1	10	0.5
Default	No data available	1	10	0.5

**This condition is only collected by exception, i.e. when the cable section is uncovered for fault repair, leak detection, construction works etc.*

B.5.18 132kV Cable (Gas)

TABLE 106: OBSERVED CONDITION INPUT - 132KV CABLE (GAS): PRESENCE OF CRYSTALLINE LEAD

Condition Criteria: Lead Crystallisation Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	Applicable to cables in the Lead sheath sub-division only: No lead crystallisation has been identified in the sheath of the cable or any other lead sheath cable within the same pneumatic section, on any occasion where the lead sheath of the cable has been exposed (e.g. during fault repair, leak location, construction works etc.).	1	10	0.5
Yes	Applicable to cables in the Lead sheath sub-division only: Evidence of lead crystallisation has been identified in the sheath of the cable or any other lead sheath cable within the same pneumatic section, on one or more occasions where the lead sheath of the cable has been exposed (e.g. during fault repair, leak location, construction works etc.).	1.8	10	8
Not applicable	This condition input is not applicable because the exposed cable within the pneumatic section is in the Aluminium sheath sub-division or the Lead sheath cable section has not been exposed.	1	10	0.5
Default	No data available	1	10	0.5

**This condition is only collected by exception, i.e. when the cable section is uncovered for fault repair, leak detection, construction works etc.*

B.5.19 Submarine Cable

TABLE 107: OBSERVED CONDITION INPUT - SUBMARINE CABLE: EXTERNAL CONDITION ARMOUR

Condition Criteria	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Good	The asset component exhibits deterioration but is fit for continued service.	1	10	0.5
Poor	e.g. visible damage to armour	1.6	10	5.5
Critical	e.g. mechanical damage to cable armour, loss of armour	1.8	10	8
Default	No data available	1	10	0.5

B.5.20 LV Poles

TABLE 108: OBSERVED CONDITION INPUT - LV POLE: VISUAL POLE CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable	No significant defects observed. Pole may be new with no/few marks. May include poles with slight damage including (but not limited to) splits and general wear where no material impact on residual strength of pole.	1	10	0.5
Some Deterioration	Minor wear on pole or physical damage that will lead to loss of strength, but the short term integrity of the pole is not compromised.	1.3	10	4.0
Substantial Deterioration	Severe damage to pole. Parts may be chipped off, rotten or disfigured. e.g. visible splits, cracks, major physical damage affecting strength.	1.8	10	8.0
Default	No data available	1	10	0.5

TABLE 109: OBSERVED CONDITION INPUT - LV POLE: POLE TOP ROT

Condition Criteria: Pole Top Rot Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	No pole top rot observed	1	10	0.5
Yes	Pole top rot is observed	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 110: OBSERVED CONDITION INPUT - LV POLE: POLE LEANING

Condition Criteria: Pole Leaning?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	The pole is vertical	1	10	0.5
Yes	The pole is not vertical	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 111: OBSERVED CONDITION INPUT - LV POLE: BIRD / ANIMAL DAMAGE

Condition Criteria: Bird/ Animal Damage?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	There is no animal damage	1	10	0.5
Yes	There is animal damage	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.21 HV Poles

TABLE 112: OBSERVED CONDITION INPUT – HV POLE: VISUAL POLE CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable	No significant defects observed. Pole may be new with no/few marks. May include poles with slight damage including (but not limited to) splits and general wear where no material impact on residual strength of pole.	1	10	0.5
Some Deterioration	Minor wear on pole or physical damage that will lead to loss of strength, but the short term integrity of the pole is not compromised.	1.3	10	4.0
Substantial Deterioration	Severe damage to pole. Parts may be chipped off, rotten or disfigured. E.g. visible splits, cracks, major physical damage affecting strength.	1.8	10	8.0
Default	No data available	1	10	0.5

TABLE 113: OBSERVED CONDITION INPUT – HV POLE: VISUAL POLE CONDITION: POLE TOP ROT

Condition Criteria: Pole Top Rot Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	No pole top rot observed	1	10	0.5
Yes	Pole top rot is observed	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 114: OBSERVED CONDITION INPUT – HV POLE: POLE LEANING

Condition Criteria: Pole Leaning?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	The pole is vertical	1	10	0.5
Yes	The pole is not vertical	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 115: OBSERVED CONDITION INPUT – HV POLE: BIRD / ANIMAL DAMAGE

Condition Criteria: Bird/ Animal Damage?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	There is no animal damage	1	10	0.5
Yes	There is animal damage	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.22 EHV Poles

TABLE 116: OBSERVED CONDITION INPUT - EHV POLE: VISUAL POLE CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable	No significant defects observed. Pole may be new with no/few marks. May include poles with slight damage including (but not limited to) splits and general wear where no material impact on residual strength of pole.	1	10	0.5
Some Deterioration	Minor wear on pole or physical damage that will lead to loss of strength, but the short term integrity of the pole is not compromised.	1.3	10	4.0
Substantial Deterioration	Severe damage to pole. Parts may be chipped off, rotten or disfigured. e.g. visible splits, cracks, major physical damage affecting strength.	1.8	10	8.0
Default	No data available	1	10	0.5

TABLE 117: OBSERVED CONDITION INPUT - EHV POLE: POLE TOP ROT

Condition Criteria: Pole Top Rot Present?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	No pole top rot observed	1	10	0.5
Yes	Pole top rot is observed	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 118: OBSERVED CONDITION INPUT - EHV POLE: POLE LEANING

Condition Criteria: Pole Leaning?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	The pole is vertical	1	10	0.5
Yes	The pole is not vertical	1.2	10	0.5
Default	No data available	1	10	0.5

TABLE 119: OBSERVED CONDITION INPUT - EHV POLE: BIRD / ANIMAL DAMAGE

Condition Criteria: Bird/ Animal Damage?	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No	There is no animal damage	1	10	0.5
Yes	There is animal damage	1.3	10	0.5
Default	No data available	1	10	0.5

B.5.23 EHV Towers (Tower Steelwork component)

TABLE 120: OBSERVED CONDITION INPUT - EHV TOWER: TOWER LEGS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	4.4	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.8	10	8
Default	No data available	1	10	0.5

TABLE 121: OBSERVED CONDITION INPUT - EHV TOWER: BRACINGS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	4.4	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.2	10	5.5
Default	No data available	1	10	0.5

TABLE 122: OBSERVED CONDITION INPUT - EHV TOWER: CROSSARMS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	4.4	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.8	10	8
Default	No data available	1	10	0.5

TABLE 123: OBSERVED CONDITION INPUT - EHV TOWER: PEAK

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	4.4	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.2	10	5.5
Default	No data available	1	10	0.5

B.5.24 EHV Towers (Tower Paintwork component)

TABLE 124: OBSERVED CONDITION INPUT - EHV TOWER: PAINTWORK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration		1	6.4	0.5
Superficial/minor deterioration	Slight rust breakthrough - up to 5% of surface area affected.	1.1	6.4	0.5
Some Deterioration	Moderate rust breakthrough - between 5% and 20% of surface area affected, and/or pitted rust	1.6	6.4	0.5
Substantial Deterioration	Severe rust breakthrough - more than 20% of surface area affected, AND/OR damaged or bent steelwork, AND/OR any blistered paintwork with evidence of severe rust underneath, painting/attention required urgently.	1.8	6.4	5.5
Default	No data available	1	6.4	0.5

B.5.25 EHV Towers (Tower Foundation component)

TABLE 125: OBSERVED CONDITION INPUT - EHV TOWER: FOUNDATION CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.95	4.4	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	4.4	0.5
Some Deterioration	e.g. minor corrosion	1.4	10	4.0
Substantial Deterioration	Insufficient integrity to support tower loading	1.8	10	8.0
Default	No data available	1	10	0.5

B.5.26 132kV Towers (Tower Steelwork component)

TABLE 126: OBSERVED CONDITION INPUT - 132KV TOWER: TOWER LEGS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	4.4	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.8	10	8
Default	No data available	1	10	0.5

TABLE 127: OBSERVED CONDITION INPUT - 132KV TOWER: BRACINGS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	4.4	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.2	10	5.5
Default	No data available	1	10	0.5

TABLE 128: OBSERVED CONDITION INPUT - 132KV TOWER: CROSSARMS

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	4.4	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.8	10	8
Default	No data available	1	10	0.5

TABLE 129: OBSERVED CONDITION INPUT - 132KV TOWER: PEAK

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable		1	4.4	0.5
Mechanically Unsafe	Signs of wasting of steel cross-section, laminated rust, holes or loss of steel at edges, severe damage - requires urgent replacement	1.2	10	5.5
Default	No data available	1	10	0.5

B.5.27 132kV Towers (Tower Paintwork component)

TABLE 130: OBSERVED CONDITION INPUT - 132KV TOWER: PAINTWORK CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration		1	6.4	0.5
Superficial/minor deterioration	Slight rust breakthrough - up to 5% of surface area affected.	1.1	6.4	0.5
Some Deterioration	Moderate rust breakthrough - between 5% and 20% of surface area affected, and/or pitted rust	1.6	6.4	0.5
Substantial Deterioration	Severe rust breakthrough - more than 20% of surface area affected, AND/OR damaged or bent steelwork, AND/OR any blistered paintwork with evidence of severe rust underneath, painting/attention required urgently.	1.8	6.4	5.5
Default	No data available	1	6.4	0.5

B.5.28 132kV Towers (Tower Foundation component)

TABLE 131: OBSERVED CONDITION INPUT - 132KV TOWER: FOUNDATION CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.95	4.4	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1	4.4	0.5
Some Deterioration	e.g. minor corrosion	1.4	10	4.0
Substantial Deterioration	Insufficient integrity to support tower loading	1.8	10	8.0
Default	No data available	1	10	0.5

B.5.29 EHV Fittings

TABLE 132: OBSERVED CONDITION INPUT - EHV FITTINGS: TOWER FITTINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required structural integrity	1.3	10	4.0
Substantial Deterioration	Loss of required structural integrity	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 133: OBSERVED CONDITION INPUT - EHV FITTINGS: CONDUCTOR FITTINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required Structural Integrity	1.3	10	4.0
Substantial Deterioration	Loss of required structural integrity	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 134: OBSERVED CONDITION INPUT - EHV FITTINGS: INSULATORS - ELECTRICAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required electrical Integrity	1.3	10	4.0
Substantial Deterioration	Loss of required electrical integrity	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 135: OBSERVED CONDITION INPUT - EHV FITTINGS: INSULATORS - MECHANICAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required structural integrity	1.3	10	4.0
Substantial Deterioration	Loss of required structural integrity	1.4	10	8.0
Default	No data available	1	10	0.5

B.5.30 132kV Fittings

TABLE 136: OBSERVED CONDITION INPUT - 132KV FITTINGS: TOWER FITTINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required Structural Integrity	1.3	10	4.0
Substantial Deterioration	Loss of required structural integrity	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 137: OBSERVED CONDITION INPUT - 132KV FITTINGS: CONDUCTOR FITTINGS CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required Structural Integrity	1.3	10	4.0
Substantial Deterioration	Loss of required structural integrity	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 138: OBSERVED CONDITION INPUT - 132KV FITTINGS: INSULATORS - ELECTRICAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required electrical integrity	1.3	10	4.0
Substantial Deterioration	Loss of required electrical integrity	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 139: OBSERVED CONDITION INPUT - 132KV FITTINGS: INSULATORS - MECHANICAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	Partial Loss of required Structural Integrity	1.3	10	4.0
Substantial Deterioration	Loss of required structural integrity	1.4	10	8.0
Default	No data available	1	10	0.5

B.5.31 EHV Tower Line Conductor

TABLE 140: OBSERVED CONDITION INPUT - EHV TOWER LINE CONDUCTOR: VISUAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	e.g. minor corrosion	1.3	10	4.0
Substantial Deterioration	e.g. bird caging, broken strands, loss of section	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 141: OBSERVED CONDITION INPUT - EHV TOWER LINE CONDUCTOR: MIDSPAN JOINTS

Condition Criteria: No. of Midspan Joints	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
0	No joints in the span. A span includes all conductors in that span	1	10	0.5
1	1 joint in the span	1.05	10	0.5
2	2 joints in the span	1.1	10	0.5
>2	More than two joints in the span	1.2	10	5.5
Default	No data available	1	10	0.5

B.5.32 132kV Tower Line Conductor

TABLE 142: OBSERVED CONDITION INPUT - 132KV TOWER LINE CONDUCTOR: VISUAL CONDITION

Condition Criteria: Observed Condition	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No deterioration	No observed deterioration	0.9	10	0.5
Superficial/minor deterioration	The asset component is fit for continued service. There is little deterioration	1.1	10	0.5
Some Deterioration	e.g. minor corrosion	1.3	10	4.0
Substantial Deterioration	e.g. bird caging, broken strands, loss of section	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 143: OBSERVED CONDITION INPUT - 132KV TOWER LINE CONDUCTOR: MIDSPAN JOINTS

Condition Criteria: No. of Midspan Joints	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
0	No joints in the span. A span includes all conductors in that span	1	10	0.5
1	1 joint in the span	1.05	10	0.5
2	2 joints in the span	1.1	10	0.5
>2	More than two joints in the span	1.2	10	5.5
Default	No data available	1	10	0.5

B.6 Measured Condition Factors

B.6.1 Overview

The following calibration tables shall be used to determine the value of each Measured Condition Input for individual assets.

The Measured Condition Inputs consist of three elements:-

i) A Condition Input Factor, which is used in the derivation of the Measured Condition Factor;
ii) a Condition Input Cap, which specifies a Health Score value that is used in the derivation of the Measured Condition Cap;
iii) a Condition Input Collar, which specifies a Health Score value that is used in the derivation of the Measured Condition Collar.

The use of Measured Condition Inputs to create the Measured Condition Modifier is described in Section 6.10.

DNOs shall map their own observed condition data to the criteria shown in these calibration tables, in order to determine the appropriate values for each of the Measured Condition Inputs. Where no data is available the default values for the Measured Condition Inputs shall be applied.

B.6.2 LV UGB

TABLE 144: MEASURED CONDITION INPUT - LV UGB: OPERATIONAL ADEQUACY

Condition Criteria: Operational Adequacy	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Operable	The LV UGB can be operated safely	1	10	0.5
Inoperable	The LV UGB cannot be operated or repaired	1.5	10	8
Default	No data available	1	10	0.5

B.6.3 LV Circuit Breaker

TABLE 145: MEASURED CONDITION INPUT - LV CIRCUIT BREAKER: OPERATIONAL ADEQUACY

Condition Criteria: Operational Adequacy	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Acceptable	The device can be operated safely	1	10	0.5
Unacceptable	The device cannot be operated safely	1.6	10	8
Default	No data available	1	10	0.5

B.6.4 LV Board (WM)

TABLE 146: MEASURED CONDITION INPUT - LV BOARD (WM): OPERATIONAL ADEQUACY

Condition Criteria: Operational Adequacy	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Operable	The LV Board can be operated safely	1	10	0.5
Inoperable - Secure	The LV Board cannot be operated but is physically secure	1.3	10	4.0
Inoperable - Hazardous	The LV Board cannot be operated and presents a hazard to either operator, the public or both	1.5	10	8.0
Default	No data available	1	10	0.5

B.6.5 LV Pillar

TABLE 147: MEASURED CONDITION INPUT - LV PILLAR: OPERATIONAL ADEQUACY

Condition Criteria: Operational Adequacy	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Operable	The LV Pillar can be operated safely	1	10	0.5
Inoperable - Secure	The LV Pillar cannot be operated but is physically secure	1.3	10	4.0
Inoperable - Hazardous	The LV Pillar cannot be operated and presents a hazard to either operator, the public or both	1.5	10	8.0
Default	No data available	1	10	0.5

B.6.6 HV Switchgear (GM) - Distribution

TABLE 148: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 149: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: DUCTOR TEST

Condition Criteria: Ductor Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The joint test result meets the manufacturers recommended value	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 150: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: OIL TESTS

Condition Criteria: Oil Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The oil test result meets the required European Standard for new oil	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 151: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: TEMPERATURE READINGS

Condition Criteria: Temperature Readings	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 152: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - DISTRIBUTION: TRIP TEST

Condition Criteria: Trip Timing Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Trip time within acceptable range for the type of switchgear	1	10	0.5
Fail	Trip time slower than acceptable time for the type of switchgear	1.4	10	0.5
Default	No data available	1	10	0.5

B.6.7 HV Switchgear (GM) - Primary

TABLE 153: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. ‘Amber’ result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. ‘Red’ result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 154: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: DUCTOR TEST

Condition Criteria: Ductor Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The joint test result meets the manufacturers recommended value	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the ‘As New’ condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the ‘As New’ condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 155: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: IR TEST

Condition Criteria: IR Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The insulation test result meets the manufacturers recommended value	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 156: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: OIL TESTS

Condition Criteria: Oil Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The oil test result meets the required European Standard for new oil	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 157: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: TEMPERATURE READINGS

Condition Criteria: Temperature Readings	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above ambient	Above ambient temperature	1	10	0.5
Substantially above ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 158: MEASURED CONDITION INPUT - HV SWITCHGEAR (GM) - PRIMARY: TRIP TEST

Condition Criteria: Trip Timing Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Trip time within acceptable range for the type of switchgear	1	10	0.5
Fail	Trip time slower than acceptable time for the type of switchgear	1.4	10	0.5
Default	No data available	1	10	0.5

B.6.8 EHV Switchgear (GM)

TABLE 159: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 160: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): DUCTOR TEST

Condition Criteria: Ductor Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The joint test result meets the manufacturers recommended value	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 161: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): IR TEST

Condition Criteria: IR Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The insulation test result meets the manufacturers recommended value	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 162: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): OIL TESTS / GAS TESTS

Condition Criteria: Oil Test/ Gas Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The oil or gas test result meets the required European Standard for new oil or gas	1	10	0.5
Up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 163: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): TEMPERATURE READINGS

Condition Criteria: Temperature Readings	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 164: MEASURED CONDITION INPUT - EHV SWITCHGEAR (GM): TRIP TEST

Condition Criteria: Trip Timing Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Trip time within acceptable range for the type of switchgear	1	10	0.5
Fail	Trip time slower than acceptable time for the type of switchgear	1.4	10	0.5
Default	No data available	1	10	0.5

B.6.9 132kV Switchgear (GM)

TABLE 165: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 166: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): DUCTOR TEST

Condition Criteria: Ductor Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The joint test result meets the manufacturers recommended value	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 167: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): IR TEST

Condition Criteria: IR Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The insulation test result meets the manufacturers recommended value	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 168: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): OIL TESTS / GAS TESTS

Condition Criteria: Oil Test/ Gas Test Results	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
As New	The oil or gas test result meets the required European Standard for new oil or gas	1	10	0.5
up to 10% deterioration from new	Up to 10% deterioration from the 'As New' condition	1.1	10	0.5
> 10% deterioration from new	Over 10% deterioration from the 'As New' condition	1.3	10	0.5
Default	No data available	1	10	0.5

TABLE 169: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): TEMPERATURE READINGS

Condition Criteria: Temperature Readings	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Ambient or Below	At or below ambient temperature	0.9	10	0.5
Above Ambient	Above ambient temperature	1	10	0.5
Substantially Above Ambient	Operating above the manufacturers recommended maximum temperature	1.1	10	0.5
Default	No data available	1	10	0.5

TABLE 170: MEASURED CONDITION INPUT - 132KV SWITCHGEAR (GM): TRIP TEST

Condition Criteria: Trip Timing Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Trip time within acceptable range for the type of switchgear	1	10	0.5
Fail	Trip time slower than acceptable time for the type of switchgear	1.4	10	0.5
Default	No data available	1	10	0.5

B.6.10 HV Transformer (GM)

TABLE 171: MEASURED CONDITION INPUT - HV TRANSFORMER (GM): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 172: MEASURED CONDITION INPUT - HV TRANSFORMER (GM): TEMPERATURE READINGS

Condition Criteria: Temperature Reading	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal	Normally expected temperature for transformer loading	1	10	0.5
Moderately High	Slightly above normally expected temperature for transformer loading	1.2	10	0.5
Very High	Significantly above normally expected temperature for transformer loading	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.11 EHV Transformer (GM) (Main Transformer Component)

TABLE 173: MEASURED CONDITION INPUT - EHV TRANSFORMER (GM): MAIN TRANSFORMER PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial Discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 174: MEASURED CONDITION INPUT - EHV TRANSFORMER (GM): TEMPERATURE READINGS

Condition Criteria: Temperature Reading	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal	Normally expected temperature for transformer loading	1	10	0.5
Moderately High	Slightly above normally expected temperature for transformer loading	1.2	10	0.5
Very High	Significantly above normally expected temperature for transformer loading	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.12 EHV Transformer (GM) (Tapchanger component)

TABLE 175: MEASURED CONDITION INPUT - EHV TRANSFORMER (GM): TAPCHANGER PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

B.6.13 132kV Transformer (GM) (Main Transformer Component)

TABLE 176: MEASURED CONDITION INPUT - 132KV TRANSFORMER (GM): MAIN TRANSFORMER PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High partial discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

TABLE 177: MEASURED CONDITION INPUT - 132KV TRANSFORMER (GM): TEMPERATURE READINGS

Condition Criteria: Temperature Reading	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Normal	Normally expected temperature for transformer loading	1	10	0.5
Moderately High	Slightly above normally expected temperature for transformer loading	1.2	10	0.5
Very High	Significantly above normally expected temperature for transformer loading	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.14 132kV Transformer (GM) (Tapchanger component)

TABLE 178: MEASURED CONDITION INPUT - 132KV TRANSFORMER (GM): TAPCHANGER PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Low or negligible levels of partial discharge indicating no issues identified (e.g. a green condition using a TEV or <10% of manufacturers recommendation	1	10	0.5
Medium	Some moderate levels of partial discharge recorded (e.g. 'Amber' result from TEV measuring device or between 10% and 30% of the manufacturers recommendation)	1.1	10	0.5
High (Not Confirmed)	High levels of partial discharge indicating possible defect with plant / equipment, requiring further investigation (e.g. 'Red' result from TEV measuring device or above manufacturers recommendation)	1.3	10	5.5
High (Confirmed)	High Partial Discharge. Source of partial discharge confirmed as potential source of failure	1.5	10	8
Default	No data available	1	10	0.5

B.6.15 EHV Cable (Non Pressurised)

TABLE 179: MEASURED CONDITION INPUT - EHV CABLE (NON PRESSURISED): SHEATH TEST

Condition Criteria: Sheath Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Satisfactory	1	10	0.5
Failed Minor	Failure requiring minor repair	1.3	10	0.5
Failed Major	Unacceptable sheath leakage or condition	1.6	10	5.5
Default	No data available	1	10	0.5

TABLE 180: MEASURED CONDITION INPUT - EHV CABLE (NON PRESSURISED): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No unusual activity detected	1	10	0.5
Medium	PD detected requiring regular monitoring	1.15	10	0.5
High	Intervention required	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 181: MEASURED CONDITION INPUT - EHV CABLE (NON PRESSURISED): FAULT HISTORY

Condition Criteria: Fault Rate (faults per annum)	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No historic faults recorded	No recorded faults or failures in the period	1	5.4	0.5
<0.01 per km	The calculated fault rate for the asset in the period	1.3	10	0.5
≥0.01 and <0.1 per km		1.6	10	5.5
≥0.1 per km		1.8	10	8
Default	No data available	1	10	0.5

B.6.16 EHV Cable (Oil)

TABLE 182: MEASURED CONDITION INPUT - EHV CABLE (OIL): LEAKAGE

Condition Criteria: Leakage Rate	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No (or very low) historic leakage recorded	No or negligible levels of leakage	1	10	0.5
Low/ moderate	Requires occasional intervention to maintain pressure	1.3	10	0.5
High	Requires regular intervention to maintain pressure	1.8	10	5.5
Very High	Requires intervention at the point of oil loss	2	10	8
Default	No data available	1	10	0.5

B.6.17 EHV Cable (Gas)

TABLE 183: MEASURED CONDITION INPUT - EHV CABLE (GAS): LEAKAGE

Condition Criteria: Leakage Rate	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No (or very low) historic leakage recorded	No or negligible levels of leakage	1	10	0.5
Low/ moderate	Requires occasional intervention to maintain pressure	1.3	10	0.5
High	Requires regular intervention to maintain pressure	1.8	10	5.5
Very High	Requires intervention at the point of gas loss	2	10	8
Default	No data available	1	10	0.5

B.6.18 132kV Cable (Non Pressurised)

TABLE 184: MEASURED CONDITION INPUT - 132KV CABLE (NON PRESSURISED): SHEATH TEST

Condition Criteria: Sheath Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Satisfactory	1	10	0.5
Failed Minor	Failure requiring minor repair	1.3	10	0.5
Failed Major	Unacceptable Sheath Leakage or Condition	1.6	10	5.5
Default	No data available	1	10	0.5

TABLE 185: MEASURED CONDITION INPUT - 132KV CABLE (NON PRESSURISED): PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No unusual activity detected	1	10	0.5
Medium	PD detected requiring regular monitoring	1.15	10	0.5
High	Intervention required	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 186: MEASURED CONDITION INPUT - 132KV CABLE (NON PRESSURISED): FAULT HISTORY

Condition Criteria: Fault Rate (faults per annum)	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No historic faults recorded	No recorded faults or failures in the period	1	5.4	0.5
<0.01 per km	The calculated fault rate for the asset in the period	1.3	10	0.5
≥0.01 and <0.1 per km		1.6	10	5.5
≥0.1 per km		1.8	10	8
Default	No data available	1	10	0.5

B.6.19 132kV Cable (Oil)

TABLE 187: MEASURED CONDITION INPUT - 132KV CABLE (OIL): LEAKAGE

Condition Criteria: Leakage Rate	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No (or very low) historic leakage recorded	No or negligible levels of leakage	1	10	0.5
Low/ moderate	Requires occasional intervention to maintain pressure	1.3	10	0.5
High	Requires regular intervention to maintain pressure	1.8	10	5.5
Very High	Requires intervention at the point of oil loss	2	10	8
Default	No data available	1	10	0.5

B.6.20 132kV Cable (Gas)

TABLE 188: MEASURED CONDITION INPUT - 132KV CABLE (GAS): LEAKAGE

Condition Criteria: Leakage Rate	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No (or very low) historic leakage recorded	No or negligible levels of leakage	1	10	0.5
Low/ moderate	Requires occasional intervention to maintain pressure	1.3	10	0.5
High	Requires regular intervention to maintain pressure	1.8	10	5.5
Very High	Requires intervention at the point of gas loss	2	10	8
Default	No data available	1	10	0.5

B.6.21 Submarine Cable

TABLE 189: MEASURED CONDITION INPUT - SUBMARINE CABLE: SHEATH TEST

Condition Criteria: Sheath Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Pass	Satisfactory	1	10	0.5
Failed Minor	Failure requiring minor repair	1.3	10	0.5
Failed Major	Unacceptable sheath leakage or condition	1.6	10	5.5
Default	No data available	1	10	0.5

TABLE 190: MEASURED CONDITION INPUT - SUBMARINE CABLE: PARTIAL DISCHARGE

Condition Criteria: Partial Discharge Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No unusual activity detected	1	10	0.5
Medium	PD detected requiring regular monitoring	1.15	10	0.5
High	Intervention required	1.5	10	5.5
Default	No data available	1	10	0.5

TABLE 191: MEASURED CONDITION INPUT - SUBMARINE CABLE: FAULT HISTORY

Condition Criteria: Fault Rate (faults per annum)	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
No historic faults recorded	No recorded faults or failures in the period	1	5.4	0.5
<0.01 per km	The calculated fault rate for the asset in the period	1.3	10	0.5
≥0.01 and <0.1 per km		1.6	10	5.5
≥0.1 per km		1.8	10	8
Default	No data available	1	10	0.5

B.6.22 LV Poles

TABLE 192: MEASURED CONDITION INPUT - LV POLE: POLE DECAY / DETERIORATION

Condition Criteria: Degree of Decay/Deterioration	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
None	Zero measured loss of strength	0.8	5.4	0.5
No Significant Decay/Deterioration	Minor loss of strength	1	6.4	0.5
High	Significant loss of residual strength, still within acceptable level	1.4	10	5.5
Very High	Residual strength below acceptable level	1.8	10	8
Default	No data available	1	10	0.5

B.6.23 HV Poles

TABLE 193: MEASURED CONDITION INPUT - HV POLE: POLE DECAY / DETERIORATION

Condition Criteria: Degree of Decay/Deterioration	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
None	Zero measured loss of strength	0.8	5.4	0.5
No Significant Decay/Deterioration	Minor loss of strength	1	6.4	0.5
High	Significant loss of residual strength, still within acceptable level	1.4	10	5.5
Very High	Residual strength below acceptable level	1.8	10	8
Default	No data available	1	10	0.5

B.6.24 EHV Poles

TABLE 194: MEASURED CONDITION INPUT - EHV POLE: POLE DECAY / DETERIORATION

Condition Criteria: Degree of Decay/Deterioration	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
None	Zero measured loss of strength	0.8	5.4	0.5
No Significant Decay/Deterioration	Minor loss of strength	1	6.4	0.5
High	Significant loss of residual strength, still within acceptable level	1.4	10	5.5
Very High	Residual strength below acceptable level	1.8	10	8
Default	No data available	1	10	0.5

B.6.25 EHV Fittings

TABLE 195: MEASURED CONDITION INPUT - EHV FITTINGS: THERMAL IMAGING

Condition Criteria: Thermal Imaging Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Ambient plus or minus 10^{0}C	1	5.4	0.5
Medium	Ambient plus 10 - 25^{0}C	1.1	10	0.5
High	Ambient plus more than 25^{0}C	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 196: MEASURED CONDITION INPUT - EHV FITTINGS: DUCTOR TEST

Condition Criteria: Ductor Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	As commissioned or up to 2.5% variance	1	5.4	0.5
Medium	As commissioned or up to 5% variance	1.1	10	0.5
High	As commissioned or over 5% variance	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.26 132kV Fittings

TABLE 197: MEASURED CONDITION INPUT - 132KV FITTINGS: THERMAL IMAGING

Condition Criteria: Thermal Imaging Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	Ambient plus or minus 10^{0}C	1	5.4	0.5
Medium	Ambient plus 10 - 25^{0}C	1.1	10	0.5
High	Ambient plus more than 25^{0}C	1.4	10	5.5
Default	No data available	1	10	0.5

TABLE 198: MEASURED CONDITION INPUT - 132KV FITTINGS: DUCTOR TEST

Condition Criteria: Ductor Test Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	As commissioned or up to 2.5% variance	1	5.4	0.5
Medium	As commissioned or up to 5% variance	1.1	10	0.5
High	As commissioned or over 5% variance	1.4	10	5.5
Default	No data available	1	10	0.5

B.6.27 EHV Tower Line Conductor

TABLE 199: MEASURED CONDITION INPUT - EHV TOWER LINE CONDUCTOR: CONDUCTOR SAMPLING

Condition Criteria: Conductor Sampling Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No obvious or minor deterioration	1	5.4	0.5
Medium/Normal	Wear is consistent with the duty and environment of the circuit	1.1	10	3.0
High	Wear indicated that an end of life condition exists	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 200: MEASURED CONDITION INPUT - EHV TOWER LINE CONDUCTOR: CORROSION MONITORING SURVEY

Condition Criteria: Corrosion Monitoring Survey Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No obvious or minor deterioration	1	5.4	0.5
Medium/Normal	Wear is consistent with the duty and environment of the circuit	1.1	10	3.0
High	Wear indicated that an end of life condition exists	1.4	10	8.0
Default	No data available	1	10	0.5

B.6.28 132kV Tower Line Conductor

TABLE 201: MEASURED CONDITION INPUT - 132KV TOWER LINE CONDUCTOR: CONDUCTOR SAMPLING

Condition Criteria: Conductor Sampling Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No obvious or minor deterioration	1	5.4	0.5
Medium/Normal	Wear is consistent with the duty and environment of the circuit	1.1	10	3.0
High	Wear indicated that an end of life condition exists	1.4	10	8.0
Default	No data available	1	10	0.5

TABLE 202: MEASURED CONDITION INPUT - 132KV TOWER LINE CONDUCTOR: CORROSION MONITORING SURVEY

Condition Criteria: Corrosion Monitoring Survey Result	Description	Condition Input Factor	Condition Input Cap	Condition Input Collar
Low	No obvious or minor deterioration	1	5.4	0.5
Medium/Normal	Wear is consistent with the duty and environment of the circuit	1.1	10	3.0
High	Wear indicated that an end of life condition exists	1.4	10	8.0
Default	No data available	1	10	0.5

B.7 Oil Test Modifier

TABLE 203: MOISTURE CONDITION STATE CALIBRATION

HV Transformer (GM) EHV Transformer (GM)			132kV Transformer (GM)		
> Moisture (ppm)	<= Moisture (ppm)	Moisture Score	> Moisture (ppm)	<= Moisture (ppm)	Moisture Score
-0.01	15.00	0	-0.01	15.00	0
15.00	30.00	2	15.00	20.00	2
30.00	40.00	4	20.00	30.00	4
40.00	50.00	8	30.00	40.00	8
50.00	10000.00	10	40.00	10000.00	10

TABLE 204: ACIDITY CONDITION STATE CALIBRATION

HV Transformer (GM)			EHV Transformer (GM)			132kV Transformer (GM)		
> Acidity (mg KOH/g)	<= Acidity (mg KOH/g)	Acidity Score	> Acidity (mg KOH/g)	<= Acidity (mg KOH/g)	Acidity Score	> Acidity (mg KOH/g)	<= Acidity (mg KOH/g)	Acidity Score
-	-	-	-0.01	0.10	0	-0.01	0.05	0
-0.01	0.15	2	0.10	0.15	2	0.05	0.10	2
0.15	0.30	4	0.15	0.30	4	0.10	0.20	4
0.30	0.50	8	0.30	0.40	8	0.20	0.30	8
0.50	10000.00	10	0.40	10000.00	10	0.30	10000.00	10

TABLE 205: BREAKDOWN STRENGTH CONDITION STATE CALIBRATION

HV Transformer (GM) EHV Transformer (GM)			132kV Transformer (GM)		
> BD Strength (kV)	<= BD Strength (kV)	BD Strength Score	> BD Strength (kV)	<= BD Strength (kV)	BD Strength Score
-0.01	30.00	10	-0.01	40.00	10
30.00	40.00	4	40.00	50.00	4
40.00	50.00	2	50.00	60.00	2
50.00	10000.00	0	60.00	10000.00	0

TABLE 206: OIL TEST FACTOR CALIBRATION

HV Transformer (GM)			EHV Transformer (GM) 132kV Transformer (GM)		
> Oil Condition Score	<= Oil Condition Score	Oil Test Factor	> Oil Condition Score	<= Oil Condition Score	Oil Test Factor
-	-	-	-0.01	50	0.90
-0.01	250	1.00	50	200	1.00
250	500	1.10	200	500	1.05
500	1,000	1.20	500	1,000	1.10
1,000	10,000	1.40	1,000	10,000	1.20

TABLE 207: OIL TEST COLLAR CALIBRATION

HV Transformer (GM)			EHV Transformer (GM) 132kV Transformer (GM)		
> Oil Condition Score	<= Oil Condition Score	Oil Test Collar	> Oil Condition Score	<= Oil Condition Score	Oil Test Collar
-	-	-	-0.01	50	0.5
-0.01	250	0.5	50	200	0.5
250	500	0.5	200	500	0.5
500	1,000	0.5	500	1,000	0.5
1,000	10,000	5.5	1,000	10,000	5.5

B.8 DGA Test Modifier

TABLE 208: HYDROGEN CONDITION STATE CALIBRATION

HV Transformer (GM) EHV Transformer (GM) 132kV Transformer (GM)		
> Hydrogen (ppm)	<= Hydrogen (ppm)	Hydrogen Condition State
-0.01	20.00	0
20.00	40.00	2
40.00	100.00	4
100.00	200.00	10
200.00	10,000.00	16

TABLE 209: METHANE CONDITION STATE CALIBRATION

HV Transformer (GM) EHV Transformer (GM) 132kV Transformer (GM)		
> Methane (ppm)	<= Methane (ppm)	Methane Condition State
-0.01	10.00	0
10.00	20.00	2
20.00	50.00	4
50.00	150.00	10
150.00	10,000.00	16

TABLE 210: ETHYLENE CONDITION STATE CALIBRATION

HV Transformer (GM) EHV Transformer (GM) 132kV Transformer (GM)		
> Ethylene (ppm)	<= Ethylene (ppm)	Ethylene Condition State
-0.01	10.00	0
10.00	20.00	2
20.00	50.00	4
50.00	150.00	10
150.00	10,000.00	16

TABLE 211: ETHANE CONDITION STATE CALIBRATION

HV Transformer (GM) EHV Transformer (GM) 132kV Transformer (GM)		
> Ethane (ppm)	<= Ethane (ppm)	Ethane Condition State
-0.01	10.00	0
10.00	20.00	2
20.00	50.00	4
50.00	150.00	10
150.00	10,000.00	16

TABLE 212: ACETYLENE CONDITION STATE CALIBRATION

HV Transformer (GM) EHV Transformer (GM) 132kV Transformer (GM)		
> Acetylene (ppm)	<= Acetylene (ppm)	Acetylene Condition State
-0.01	1.00	0
1.00	5.00	2
5.00	20.00	4
20.00	100.00	8
100.00	10,000.00	10

TABLE 213: DGA CHANGE CATEGORY CALIBRATION

EHV Transformer (GM) 132kV Transformer (GM)		
> % Change	<= % Change	Change Category
-1,000.00	-5.00	Negative
-5.00	5.00	Neutral
5.00	25.00	Small
25.00	100.00	Significant
100.00	1,000.00	Large

TABLE 214: DGA TEST FACTOR CALIBRATION

EHV Transformer (GM) 132kV Transformer (GM)	
> % Change	DGA Test Factor
Negative	0.90
Neutral	1.00
Small	1.10
Significant	1.20
Large	1.50

B.9 FFA Test Modifier

TABLE 215: FFA TEST FACTOR

HV Transformer (GM) EHV Transformer (GM) 132kV Transformer (GM)		
> FFA value (ppm)	<= FFA value (ppm)	FFA Test Factor
-0.01	4.00	1.00
4.00	5.00	1.10
5.00	6.00	1.25
6.00	7.00	1.40
7.00		1.60

B.10 Ageing Reduction Factor

TABLE 216: AGEING REDUCTION FACTOR

Current Health Score	Ageing Reduction Factor
< 2	1
2 to 5.5	((Current Health Score - 2)/ 7) + 1
> 5.5	1.5

APPENDIX C
INTERVENTIONS

Where work is carried out to either replace or refurbish an asset, that work will impact the value of the PoF and in some cases the CoF of the asset and hence a revised value of risk can be calculated for that asset. The change in the risk of the asset will be calculated by changes to the assets condition as observed or measured, being placed in the model and the model run to determine these changes. The change in risk will be calculated as the level of risk pre-intervention less the risk post-intervention.

Where a DNO needs to predict changes to the value of the overall risk present on their network due to their proposed work programme prior to that work being carried out, then the actual condition of the plant post intervention will not be able to be recorded. This is especially a problem where a refurbishment is proposed. In these cases, the principles within this appendix will be used and suitable assumption will be permitted. These assumptions will be stated when submitting the results to Ofgem.

TABLE 217: INPUT DATA AFFECTED BY REFURBISHMENT INTERVENTIONS

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected by Intervention
Complete replacement of the operating mechanism (ACB)	LV Switchgear	LV Circuit Breaker	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of complete feeder way	LV Switchgear	LV Pillar (ID), LV Pillar (OD at Substation) & LV Pillar (OD not at Substation)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete factory refurbishment	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary, 6.6/11kV RMU, 6.6/11kV Switch (GM), 6.6/11kV X-type RMU, 20kV CB (GM) Secondary, 20kV RMU & 20kV Switch (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete Refurbishment (factory or onsite) e.g. strip down & rebuild, replacing all worn parts	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary, 6.6/11kV RMU, 6.6/11kV Switch (GM), 6.6/11kV X-type RMU, 20kV CB (GM) Secondary, 20kV RMU & 20kV Switch (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete replacement of the operating mechanism	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary, 6.6/11kV RMU, 6.6/11kV Switch (GM), 6.6/11kV X-type RMU, 20kV CB (GM) Secondary, 20kV RMU & 20kV Switch (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary, 6.6/11kV RMU, 6.6/11kV Switch (GM), 6.6/11kV X-type RMU, 20kV CB (GM) Secondary, 20kV RMU & 20kV Switch (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of the moving portion (truck) in withdrawable equipment	HV Switchgear (GM) - Distribution	6.6/11kV CB (GM) Secondary & 20kV CB (GM) Secondary	i) Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Increase the Expected Life by 20 years
Complete factory refurbishment	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected by Intervention
Complete Refurbishment (factory or onsite) e.g. strip down & rebuild, replacing all worn parts	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete replacement of the operating mechanism	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of the moving portion (truck) in withdrawable equipment	HV Switchgear (GM) - Primary	6.6/11kV CB (GM) Primary & 20kV CB (GM) Primary	i) Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Increase the Expected Life by 20 years
Complete Refurbishment (factory or onsite) e.g. strip down & rebuild, replacing all worn parts	EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID)(GM), 33kV CB (Air Insulated Busbars)(OD)(GM), 33kV CB (Gas Insulated Busbars)(ID)(GM), 33kV CB (Gas Insulated Busbars)(OD)(GM), 33kV RMU, 33kV Switch (GM), 66kV CB (Air Insulated Busbars)(ID)(GM), 66kV CB (Air Insulated Busbars)(OD)(GM), 66kV CB (Gas Insulated Busbars)(ID)(GM) & 66kV CB (Gas Insulated Busbars)(OD)(GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete replacement of the operating mechanism	EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID)(GM), 33kV CB (Air Insulated Busbars)(OD) (GM), 33kV CB (Gas Insulated Busbars)(ID)(GM), 33kV CB (Gas Insulated Busbars)(OD) (GM), 33kV RMU, 33kV Switch (GM), 66kV CB (Air Insulated Busbars)(ID)(GM), 66kV CB (Air Insulated Busbars)(OD) (GM), 66kV CB (Gas Insulated Busbars)(ID)(GM) & 66kV CB (Gas Insulated Busbars)(OD)(GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID)(GM), 33kV CB (Air Insulated Busbars)(OD) (GM), 33kV CB (Gas Insulated Busbars)(ID)(GM), 33kV CB (Gas Insulated Busbars)(OD) (GM), 33kV RMU, 33kV Switch (GM), 66kV CB (Air Insulated Busbars)(ID)(GM), 66kV CB (Air Insulated Busbars)(OD)(GM), 66kV CB (Gas Insulated Busbars)(ID)(GM) & 66kV CB (Gas Insulated Busbars)(OD)(GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected by Intervention
Replacement of the moving portion (truck) in withdrawable equipment	EHV Switchgear (GM)	33kV CB (Air Insulated Busbars)(ID)(GM), 33kV CB (Air Insulated Busbars)(OD) (GM) & 33kV CB (Gas Insulated Busbars)(ID)(GM)	i) Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Increase the Expected Life by 20 years
Complete Refurbishment (factory or onsite) e.g. strip down & rebuild, replacing all worn parts	132kV Switchgear	132kV CB (Air Insulated Busbars)(ID)(GM), 132kV CB (Air Insulated Busbars)(OD) (GM), 132kV CB (Gas Insulated Busbars)(ID)(GM) & 132kV CB (Gas Insulated Busbars)(OD)(GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete replacement of the operating mechanism	132kV Switchgear	132kV CB (Air Insulated Busbars)(ID)(GM), 132kV CB (Air Insulated Busbars)(OD) (GM), 132kV CB (Gas Insulated Busbars)(ID)(GM) & 132kV CB (Gas Insulated Busbars)(OD)(GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	132kV Switchgear	132kV CB (Air Insulated Busbars)(ID)(GM), 132kV CB (Air Insulated Busbars)(OD)(GM), 132kV CB (Gas Insulated Busbars)(ID)(GM) & 132kV CB (Gas Insulated Busbars)(OD)(GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Complete factory refurbishment	HV Transformer (GM)	6.6/11kV Transformer (GM) & 20kV Transformer (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Installation of replacement windings	HV Transformer (GM)	6.6/11kV Transformer (GM) & 20kV Transformer (GM)	i) Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Revise age to reflect time elapsed since Refurbishment undertaken
On site processing to recondition oil to remove moisture and acidity from windings	HV Transformer (GM)	6.6/11kV Transformer (GM) & 20kV Transformer (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cooling radiators	HV Transformer (GM)	6.6/11kV Transformer (GM) & 20kV Transformer (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs and Measured Condition Inputs
Replacement of cable boxes	HV Transformer (GM)	6.6/11kV Transformer (GM) & 20kV Transformer (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs and Measured Condition Inputs
Complete factory refurbishment	EHV Transformer	33kV Transformer (GM) & 66kV Transformer (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected by Intervention
Installation of replacement windings	EHV Transformer	33kV Transformer (GM) & 66kV Transformer (GM)	i) Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs, Oil Test Modifier, DGA Test Modifier, FFA Test Modifier and Reliability Modifier; and ii) Revise age to reflect time elapsed since Refurbishment undertaken
On site processing to recondition oil to remove moisture and acidity from windings	EHV Transformer	33kV Transformer (GM) & 66kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing Oil Test Modifier
Replacement of bushings	EHV Transformer	33kV Transformer (GM) & 66kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cooling radiators	EHV Transformer	33kV Transformer (GM) & 66kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	EHV Transformer	33kV Transformer (GM) & 66kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of gaskets & seals	EHV Transformer	33kV Transformer (GM) & 66kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of Tapchangers or full replacement of Tapchanger mechanism	EHV Transformer	33kV Transformer (GM) & 66kV Transformer (GM)	i) Reassess Health Score Modifier for Tapchanger subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Where Tapchanger is replaced: revise age of Tapchanger subcomponent, used in the calculation of Initial Health Score, to the age of the new Tapchanger
Complete factory refurbishment	132kV Transformer	132kV Transformer (GM)	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected by Intervention
Installation of replacement windings	132kV Transformer	132kV Transformer (GM)	i) Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs, Oil Test Modifier, DGA Test Modifier, FFA Test Modifier and Reliability Modifier; and ii) Revise age to reflect time elapsed since Refurbishment undertaken
On site processing to recondition oil to remove moisture and acidity from windings	132kV Transformer	132kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing Oil Test Modifier
Replacement of bushings	132kV Transformer	132kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cooling radiators	132kV Transformer	132kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of cable boxes	132kV Transformer	132kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of gaskets & seals	132kV Transformer	132kV Transformer (GM)	Reassess Health Score Modifier for Main Transformer subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier
Replacement of Tapchangers or full replacement of Tapchanger mechanism	132kV Transformer	132kV Transformer (GM)	i) Reassess Health Score Modifier for Tapchanger subcomponent by reassessing relevant Observed Condition Inputs, Measured Condition Inputs and Reliability Modifier; and ii) Where Tapchanger is replaced: revise age of Tapchanger subcomponent, used in the calculation of Initial Health Score, to the age of the new Tapchanger
Pole Strengthening (e.g. clamping a steelwork supporting bracket to an existing pole)	LV Poles	LV Poles	Reassess Health Score Modifier by reassessing Pole Decay/Deterioration Measured Condition Inputs
Small footprint steel masts: Replacement of individual steelwork members	LV Poles	LV Poles	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs and Measured Condition Inputs
Pole Strengthening (e.g. clamping a steelwork supporting bracket to an existing pole)	HV Poles	6.6/11kV Poles & 20kV Poles	Reassess Health Score Modifier by reassessing Pole Decay/Deterioration Measured Condition Inputs

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected by Intervention
Small footprint steel masts: Replacement of individual steelwork members	HV Poles	6.6/11kV Poles & 20kV Poles	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs and Measured Condition Inputs
Pole Strengthening (e.g. clamping a steelwork supporting bracket to an existing pole)	EHV Pole	33kV Pole & 66kV Pole	Reassess Health Score Modifier by reassessing Pole Decay/Deterioration Measured Condition Inputs
Small footprint steel masts: Replacement of individual steelwork members	EHV Pole	33kV Pole & 66kV Pole	Reassess Health Score Modifier by reassessing relevant Observed Condition Inputs and Measured Condition Inputs
Painting of Tower	EHV Tower	33kV Tower & 66kV Tower	i) Reassess Health Score Modifier for Tower Paintwork subcomponent by reassessing Paintwork Condition Input; and ii) revise age of Tower Paintwork subcomponent, used in the calculation of Initial Health Score, to the time elapsed since the Tower was most recently painted
Replacement of individual steelwork members	EHV Tower	33kV Tower & 66kV Tower	Reassess Health Score Modifier for the Tower Steelwork subcomponent by reassessing relevant Observed Condition Inputs
Replacement of Tower foundations	EHV Tower	33kV Tower & 66kV Tower	Reassess Health Score Modifier for the Tower Foundation subcomponent by reassessing relevant Observed Condition Inputs
Painting of Tower	132kV Tower	132kV Tower	i) Reassess Health Score Modifier for Tower Paintwork subcomponent by reassessing Paintwork Condition Input ii) revise age of Tower Paintwork subcomponent, used in the calculation of Initial Health Score, to the time elapsed since the Tower was most recently painted
Replacement of individual steelwork members	132kV Tower	132kV Tower	Reassess Health Score Modifier for the Tower Steelwork subcomponent by reassessing relevant Observed Condition Inputs
Replacement of Tower foundations	132kV Tower	132kV Tower	Reassess Health Score Modifier for the Tower Foundation subcomponent by reassessing relevant Observed Condition Inputs

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected by Intervention
Replacement/ remaking of all cable joints and terminations (including sealing ends) within a pneumatic section – where undertaken as a single planned intervention	EHV Cable (Gas)	33kV UG Cable (Gas) & 66kV UG Cable (Gas)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input) This shall be performed by regarding the leakage history for any period prior to the completion of the refurbishment work as having no leakage, when determining the Leakage Rate Condition Input for the refurbished cable section, in any assessment of Health Score subsequent to the refurbishment works having been undertaken.
Replacement/ remaking of all cable joints and terminations (including sealing ends) within a pneumatic section – where undertaken as a single planned intervention	EHV Cable (Oil)	33kV UG Cable (Oil) & 66kV UG Cable (Oil)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input) This shall be performed by regarding the leakage history for any period prior to the completion of the refurbishment work as having no leakage, when determining the Leakage Rate Condition Input for the refurbished cable section, in any assessment of Health Score subsequent to the refurbishment works having been undertaken.
Replacement/ remaking of all cable joints and terminations (including sealing ends) within a pneumatic section – where undertaken as a single planned intervention	132kV Cable (Gas)	132kV UG Cable (Gas)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input) This shall be performed by regarding the leakage history for any period prior to the completion of the refurbishment work as having no leakage, when determining the Leakage Rate Condition Input for the refurbished cable section, in any assessment of Health Score subsequent to the refurbishment works having been undertaken.

Refurbishment Intervention Activity	Health Index Asset Category	Asset Register Category	Input Data Affected by Intervention
Replacement/ remaking of all cable joints and terminations (including sealing ends) within a pneumatic section – where undertaken as a single planned intervention	132kV Cable (Oil)	132kV UG Cable (Oil)	Reassess Health Score Modifier by reassessing relevant Measured Condition Inputs (incl. Leakage Rate Condition Input) This shall be performed by regarding the leakage history for any period prior to the completion of the refurbishment work as having no leakage, when determining the Leakage Rate Condition Input for the refurbished cable section, in any assessment of Health Score subsequent to the refurbishment works having been undertaken.

APPENDIX D
CALIBRATION – CONSEQUENCES OF FAILURE

D.1 Financial

D.1.1 Reference Financial Cost of Failure

The Reference Financial Cost of Failure is derived from an assessment of the likely repair costs incurred by the failure of the asset in each of its three failure modes[3]; incipient, degraded and catastrophic and relative proportions of each failure mode type (as a proportion of the total number of failures).

$$\begin{aligned}&\textbf{Reference Financial Cost of Failure} = \\&(\textbf{Proportion of Failures that are Incipient Failure} \times \textbf{Likely Cost of Incipient Failure}) \\&+ (\textbf{Proportion of Failures that are Degraded Failures} \times \textbf{Likely Cost of Degraded Failure}) \\&+ (\textbf{Proportion of Failures that are Catastrophic Failures} \times \textbf{Likely Cost of Catastrophic Failure})\end{aligned}$$

EQ. 27

Where:

- *Proportion of Failures that are Incipient Failures represents the expected number of Incipient Failures as a percentage of the total number of Functional Failures.*
- *Proportion of Failures that are Degraded Failures represents the expected number of Degraded Failures as a percentage of the total number of Functional Failures.*
- *Proportion of Failures that are Catastrophic Failures represents the expected number of Catastrophic Failures as a percentage of the total number of Functional Failures.*
- *Likely Cost of Failure is the cost to return the asset to service (which may extend to full replacement of the asset). This is determined based on the three failure modes considered:-*
    - *<u>Incipient:</u> The costs associated with addressing an Incipient Failure would not usually necessitate full asset replacement. Unless otherwise stated, a value equivalent to 10% of the Asset Replacement Costs[4] has been adopted.*
    - *<u>Degraded:</u> The costs associated with addressing a Degraded Failure would not usually necessitate full asset replacement; however, the works would normally be over and above those associated with addressing an Incipient Failure. Unless otherwise stated, a value equivalent to 25% of the Asset Replacement Costs has been adopted.*
    - *<u>Catastrophic</u>: A failure of this type would necessitate full asset replacement. Asset Replacement Costs have therefore been adopted, unless otherwise stated.*

For Pressurised Cables (i.e. UG Cable (Gas) or UG Cable (Oil) assets), leakage of the pressurising fluid (i.e. gas or oil) that is addressed by topping up the fluid is considered, within the Functional Failures, as an Incipient Failure. The financial costs associated with Incipient Failures for these Asset Categories reflect the costs of such activity.

In establishing the generic and common PoF curves to describe the relative relationship between asset Health Score and PoF (Section 6.1) the number of failures by failure type (Incipient/Degraded/Catastrophic Failure) has been established in accordance with the definitions described in Section 4.2.

[3] As defined in Appendix A – Functional Failures
[4] As defined in Ofgem's expert view of industry costs as used in the cost assessment for the RIIO-ED1 Final Determination

Based on this understanding the relative proportions of a failure being an Incipient, Degraded or Catastrophic Failure have been determined for each Asset Category as outlined in Table 218.

TABLE 218: REFERENCE FINANCIAL COST OF FAILURE

Asset Register Category	Relative Proportion of Failure Modes (as a % of total Functional Failures)			Likely Cost of Failure			Reference Financial Cost of Failure*
	I	D	C	I	D	C[4]	
LV Poles	20%	70%	10%	£163	£1,631	£1,631	£1,337
6.6/11kV Poles	20%	70%	10%	£233	£2,333	£2,333	£1,913.00
20kV Poles	20%	70%	10%	£280	£2,799	£2,799	£2,295.00
33kV Pole	20%	70%	10%	£300	£3,007	£3,007	£2,466.00
66kV Pole	20%	70%	10%	£453	£4,534	£4,534	£3,718.00
33kV Tower	80%	19.95%	0.05%	£5,177	£12,942	£51,771	£6,749.00
66kV Tower	80%	19.95%	0.05%	£9,700	£24,251	£97,000	£12,647.00
132kV Tower	80%	19.95%	0.05%	£11,216	£28,041	£112,163	£14,623.00
33kV Fittings	80%	15%	5%	£136	£339	£1,353	£227.00
66kV Fittings	80%	15%	5%	£174	£436	£1,742	£292.00
132kV Fittings	80%	15%	5%	£290	£724	£2,896	£485.00
33kV OHL (Tower Line) Conductor	0%	85%	15%	£0	£15,472	£30,945	£17,793.00
66kV OHL Conductor	0%	85%	15%	£0	£20,522	£41,043	£23,600.00
132kV OHL (Tower Line) Conductor	0%	85%	15%	£0	£17,746	£35,493	£20,408.00
HV Sub Cable	0%	0%	100%	£3,640	£9,100	£181,996	£181,996.00
33kV UG Cable (Non Pressurised)	0%	0%	100%	£3,164	£7,911	£31,644	£31,644.00
33kV UG Cable (Oil)	99%	0.09%	0.01%	£120	£7,911	£31,644	£129.00
33kV UG Cable (Gas)	99%	0.50%	0.50%	£120	£7,911	£31,644	£317.00
66kV UG Cable (Non Pressurised)	0%	0%	100%	£6,402	£16,006	£64,021	£64,021.00
66kV UG Cable (Oil)	99%	0.09%	0.01%	£120	£16,006	£64,021	£140.00
66kV UG Cable (Gas)	99%	0.50%	0.50%	£120	£16,006	£64,021	£519.00
132kV UG Cable (Non Pressurised)	0%	0%	100%	£10,924	£27,310	£109,244	£109,244.00
132kV UG Cable (Oil)	99%	0.09%	0.01%	£120	£27,310	£109,244	£154.00
132kV UG Cable (Gas)	99%	0.50%	0.50%	£120	£27,310	£109,244	£802.00
EHV Sub Cable	0%	0%	100%	£5,706	£14,266	£285,322	£285,322.00
132kV Sub Cable	0%	0%	100%	£9,611	£24,027	£480,542	£480,542.00
LV Circuit Breaker	15%	25%	60%	£601	£1,502	£6,007	£4,070.00
LV Pillar (ID)	15%	25%	60%	£837	£2,092	£8,367	£5,669.00
LV Pillar (OD at Substation)	15%	25%	60%	£911	£2,277	£9,107	£6,170.00
LV UGB & LV Pillar (OD not at Substation)	15%	25%	60%	£506	£1,265	£5,061	£3,429.00
LV Board (WM)	15%	25%	60%	£1,156	£2,890	£11,562	£7,833.00
LV Board (X-type Network) (WM)	15%	25%	60%	£1,365	£3,411	£13,644	£9,244.00
6.6/11kV CB (GM) Primary	45%	50%	5%	£3,448	£8,621	£34,485	£7,586.00
6.6/11kV CB (GM) Secondary	15%	25%	60%	£1,027	£2,567	£10,272	£6,959.00
6.6/11kV Switch (GM)	15%	25%	60%	£777	£1,944	£7,774	£5,267.00
6.6/11kV RMU	15%	25%	60%	£1,452	£3,630	£14,523	£9,839.00
6.6/11kV X-type RMU	15%	25%	60%	£1,965	£4,914	£19,652	£13,314.00
20kV CB (GM) Primary	45%	50%	5%	£4,320	£10,800	£43,202	£9,504.00
20kV CB (GM) Secondary	15%	25%	60%	£1,064	£2,662	£10,648	£7,214.00
20kV Switch (GM)	15%	25%	60%	£901	£2,253	£9,010	£6,104.00
20kV RMU	15%	25%	60%	£1,479	£3,699	£14,795	£10,024.00
33kV CB (Air Insulated Busbars)(ID)(GM)	45%	50%	5%	£6,597	£16,492	£65,971	£14,513.00
33kV CB (Air Insulated Busbars)(OD)(GM)	45%	50%	5%	£8,122	£20,307	£81,224	£17,870.00
33kV CB (Gas Insulated Busbars)(ID)(GM)	45%	50%	5%	£9,993	£24,981	£99,924	£21,984.00
33kV CB (Gas Insulated Busbars)(OD)(GM)	45%	50%	5%	£9,993	£24,981	£99,924	£21,984.00

Asset Register Category	Relative Proportion of Failure Modes (as a % of total Functional Failures)			Likely Cost of Failure			Reference Financial Cost of Failure*
	I	D	C	I	D	C[4]	
33kV Switch (GM)	45%	50%	5%	£4,662	£11,656	£46,621	£10,257.00
33kV RMU	45%	50%	5%	£11,521	£28,804	£115,214	£25,347.00
66kV CB (Air Insulated Busbars)(ID)(GM)	45%	50%	5%	£13,150	£32,875	£131,499	£28,930.00
66kV CB (Air Insulated Busbars)(OD)(GM)	45%	50%	5%	£21,024	£52,559	£210,237	£46,252.00
66kV CB (Gas Insulated Busbars)(ID)(GM)	45%	50%	5%	£23,716	£59,291	£237,163	£52,176.00
66kV CB (Gas Insulated Busbars)(OD)(GM)	45%	50%	5%	£23,716	£59,291	£237,163	£52,176.00
132kV CB (Air Insulated Busbars)(ID)(GM)	45%	50%	5%	£36,860	£92,150	£368,601	£81,092.00
132kV CB (Air Insulated Busbars)(OD)(GM)	45%	50%	5%	£17,355	£43,387	£173,549	£38,181.00
132kV CB (Gas Insulated Busbars)(ID)(GM)	45%	50%	5%	£76,769	£191,923	£767,691	£168,892.00
132kV CB (Gas Insulated Busbars)(OD)(GM)	45%	50%	5%	£76,769	£191,923	£767,691	£168,892.00
6.6/11kV Transformer (GM)	15%	25%	60%	£1,372	£3,431	£13,722	£9,297.00
20kV Transformer (GM)	15%	25%	60%	£1,563	£3,906	£15,624	£10,585.00
33kV Transformer (GM)	45%	50%	5%	£39,863	£99,657	£398,629	£87,698.00
66kV Transformer (GM)	45%	50%	5%	£61,270	£153,178	£612,709	£134,796.00
132kV Transformer (GM)	45%	50%	5%	£119,552	£298,880	£1,195,522	£263,015.00

* - values rounded to nearest £ for presentation in this table

[4] These are based on Ofgem's expert view of industry costs from the final determination cost assessment process from RIIO-ED1, inflated to 2020/21 prices. For cables and conductor are expressed on a per km basis; however, the lengths replaced under fault conditions are typically less than that. Further, the cost of replacing these shorter lengths of cable or conductor is not directionally proportional to the cost of replacing much greater lengths as part of planned replacements works (i.e. the basis on which replacement costs are established). For the purposes of establishing the Reference Financial Consequence it is assumed that 10% of the costs incurred per km of activity would be incurred in carrying out a repair (typical length of 50m with a factor of 2 to reflect the lower efficiency for these types of works). For subsea cable the typical length replaced during a repair is 500m and therefore the cost of a Catastrophic Failure has been assumed to be 50% of the costs incurred per km (i.e. with no further efficiency adjustment factor).

D.1.2 Financial Consequence Factors

As described in Section 7.3.3 the resulting Reference Financial Cost of Failure value can then be modified for individual assets within an Asset Category based on the application of a Type Financial Factor and/or an Access Financial Factor to result in a Financial CoF that reflects the characteristics of an individual asset of that type.

D1.2.1 TYPE FINANCIAL FACTORS

Type Financial Factors other than 1, may be applied to those Asset Categories shown in Table 219, using the Type Financial Factor criteria shown. For all other Asset Categories this Factor shall be set to 1. Similarly, the default value of the Type Financial Factor shall be 1.

TABLE 219: TYPE FINANCIAL FACTORS

Asset Register Category	Type Financial Factor Criteria	Type Financial Factor
LV Poles	Pole (excluding terminal poles)	1
	Pole (terminal poles)	1.2
	Steel Poles	2
LV Board (WM)	Non Asbestos clad	1
	Asbestos clad	2
LV Board (X-type Network) (WM)	Non Asbestos clad	1
	Asbestos clad	2
6.6/11kV Poles	Pole (supporting conductor only)	1
	Pole (supporting plant or equipment)	1.7
	Small footprint steel masts	2
20kV Poles	Pole (supporting conductor only)	1
	Pole (supporting plant or equipment)	1.7
	Small footprint steel masts	2
6.6/11kV Transformer (GM)	≥750kVA	1.15
	≥500kVA and <750kVA	1
	<500kVA	0.85
20kV Transformer (GM)	≥750kVA	1.15
	≥500kVA and <750kVA	1
	<500kVA	0.85
33kV Pole	Pole (supporting conductor only)	1
	Pole (supporting plant or equipment)	1.7
	Small footprint steel masts	2
66kV Pole	Pole (supporting conductor only)	1
	Pole (supporting plant or equipment)	1.7
	Small footprint steel masts	2
33kV Tower	Suspension	1
	Tension	1.05
	Terminal	1.1
66kV Tower	Suspension	1
	Tension	1.05
	Terminal	1.1

Asset Register Category	Type Financial Factor Criteria	Type Financial Factor
33kV Transformer (GM)	33/20kV, >20MVA CMR equivalent	1.25
	33/20kV, >10MVA and ≤20MVA CMR equivalent	1.1
	33/20kV, ≤10MVA CMR equivalent	1
	33/11 or 6.6kV, >20MVA CMR equivalent	1.1
	33/11 or 6.6kV, >10MVA and ≤20MVA CMR equivalent	1
	33/11 or 6.6kV, ≤10MVA CMR equivalent	0.9
66kV Transformer (GM)	66/20kV, >20MVA CMR equivalent	1.25
	66/20kV, >10MVA and ≤20MVA CMR equivalent	1.1
	66/20kV, ≤10MVA CMR equivalent	1
	66/33kV	1.1
	66/11/11kV	1.1
	66/11 or 6.6kV, >20MVA CMR equivalent	1.1
	66/11 or 6.6kV, >10MVA and ≤20MVA CMR equivalent	1
	66/11 or 6.6kV, ≤10MVA CMR equivalent	0.9
33kV Fittings	Suspension	1
	Tension	2
66kV Fittings	Suspension	1
	Tension	2
132kV Fittings	Suspension	1
	Tension	2
132kV Tower	Suspension	1
	Tension	1.05
	Terminal	1.1
132kV Transformer (GM)	132/66kV, ≤60MVA	1.05
	132/66kV, >60MVA	1.15
	132/33kV, ≤60MVA	0.9
	132/33kV, >60MVA	1
	132/11/11kV	1.1
	132/11kV	0.85
	132/20kV	0.95
	132/20/20kV	1.1

D1.2.2 ACCESS FINANCIAL FACTORS

Access Financial Factors other than 1, may be applied to those Asset Categories shown in Table 220 and Table 221, using the criteria shown. For all other Asset Categories this factor shall be set to 1. Similarly, the default value of Access Financial Factor shall be 1.

TABLE 220: ACCESS FACTOR: OHL

	Access Factor	
Asset Category	**Type A Criteria - Normal Access (& Default Value)**	**Type B Criteria - Major Crossing (e.g. associated span crosses railway line, major road, large waterway etc.)**
LV OHL Support	1	3
HV OHL Support - Poles	1	3
EHV OHL Support - Poles	1	3
EHV OHL Support - Towers	1	1.5
EHV OHL Fittings (Tower Lines)	1	2
EHV OHL Conductors (Tower Lines)	1	2
132kV OHL Support - Tower	1	1.5
132kV OHL Fittings (Tower Lines)	1	2
132kV OHL Conductors (Tower Lines)	1	2

TABLE 221: ACCESS FACTOR: SWITCHGEAR & TRANSFORMER ASSETS

	Access Factor		
Asset Category	**Type A Criteria - Normal Access (& Default Value)**	**Type B Criteria - Constrained Access or Confined Working Space**	**Type C Criteria - Underground substation**
LV Switchgear	1	1.25	1.7
HV Transformer (GM)	1	1.25	2
HV Switchgear (GM) - Distribution	1	1.25	1.7
HV Switchgear (GM) - Primary	1	1.15	1.3
EHV Switchgear (GM)	1	1.1	1.25
132kV Switchgear	1	1.1	1.2
EHV Transformer (GM)	1	1.1	1.35
132kV Transformer (GM)	1	1.1	1.25

D.2 Safety

D.2.1 Reference Safety Cost of Failure

The Reference Safety Cost of Failure is derived by considering the probability that a failure could result in an accident, serious injury or fatality; and the cost of a Lost Time Accident (LTA) or Death or Serious Injury (DSI) as appropriate.

$$\text{Reference Safety Cost of Failure} = \big((\text{Probability of LTA} \times \text{Cost of LTA}) + \big((\text{Probability of DSI to the Public} + \text{Probability of DSI to the Staff}\big) \times (\text{Cost of DSI})\big) \times \text{Disproportion Factor}$$

EQ. 30

Where:

- *Cost of LTA is the Reference Cost of a Lost Time Accident as shown in* Table 222
- *Cost of DSI is the Reference Cost of a Death or Serious Injury as shown in* Table 222
- *Disproportion Factor is explained later in this section*

The Reference Safety Costs for 'death or serious injury' and 'accident' are based on the HSE's GB cross-industry wide appraisal values for fatal injuries and for non-fatal injuries. These represent a quantification of the societal value of preventing an LTA or DSI.

TABLE 222: REFERENCE SAFETY COST

Reference Safety Cost	Value (£)
Lost Time Accident	£9,130
Death or Serious Injury to public	£1,810,495
Death or Serious Injury to staff	

In addition, a disproportion factor recognising the high risk nature of the electricity distribution industry is applied. Such disproportion factors are described by the HSE guidance when identifying reasonably practicable costs of mitigation. This value is not mandated by the HSE, but they state that they believe that "the greater the risk, the more should be spent in reducing it, and the greater the bias should be on the side of safety". They also suggest that the extent of the bias must be argued in the light of all the circumstances and that the factor is unlikely to be higher than 10.

In the Methodology, the factor is set to 6.25, which serves to set the current value of a DSI at £11.3m.

TABLE 223: REFERENCE SAFETY COST - DISPROPORTION FACTOR

Reference Safety Cost	Value
Disproportion Factor	6.25

In terms of the probability that a failure could result in an LTA or DSI event, the values have been derived from an assessment of both disruptive and non-disruptive failure probabilities for these events based on bottom up assessments of faults. The results of this analysis are shown in Table 224. These have been evaluated for each Asset Category using the following event tree:-

i) probability that event could be hazardous;
ii) probability that person who is present suffers the effect; and
iii) probability that affected person is present when fault occurs.

The Reference Safety Cost of Failure for each Asset Category calculated based on EQ. 30 is also shown in Table 224.

TABLE 224: REFERENCE SAFETY PROBABILITIES AND COST OF FAILURE

Asset Register Category	PROBABILITY OF EVENT PER ASSET FAILURE			Reference Safety Cost of Failure*
	Lost Time Accident	Death or Serious Injury to public	Death or Serious Injury to staff	
LV Poles	0.000816	0.00003264	0.00001632	£601
6.6/11kV Poles	0.000272	0.00001088	0.00000544	£200
20kV Poles	0.000272	0.00001088	0.00000544	£200
33kV Pole	0.000272	0.00001088	0.00000544	£200
66kV Pole	0.000272	0.00001088	0.00000544	£200
33kV Tower	0.000136	0.00000544	0.0000272	£377
66kV Tower	0.000136	0.00000544	0.0000272	£377
132kV Tower	0.000136	0.00000544	0.0000272	£377
33kV Fittings	0.000544	0.00002176	0.0001088	£1,508
66kV Fittings	0.000544	0.00002176	0.0001088	£1,508
132kV Fittings	0.000544	0.00002176	0.0001088	£1,508
33kV OHL (Tower Line) Conductor	0.000544	0.00002176	0.0001088	£1,508
66kV OHL Conductor	0.000544	0.00002176	0.0001088	£1,508
132kV OHL (Tower Line) Conductor	0.000544	0.00002176	0.0001088	£1,508
HV Sub Cable	0.00000075	0.000000075	0.000000075	£2
33kV UG Cable (Non Pressurised)	0.00000075	0.000000075	0.000000075	£2
33kV UG Cable (Oil)	0.00000075	0.000000075	0.000000075	£2
33kV UG Cable (Gas)	0.00000075	0.000000075	0.000000075	£2
66kV UG Cable (Non Pressurised)	0.00000075	0.000000075	0.000000075	£2
66kV UG Cable (Oil)	0.00000075	0.000000075	0.000000075	£2
66kV UG Cable (Gas)	0.00000075	0.000000075	0.000000075	£2
132kV UG Cable (Non Pressurised)	0.00000075	0.000000075	0.000000075	£2
132kV UG Cable (Oil)	0.00000075	0.000000075	0.000000075	£2
132kV UG Cable (Gas)	0.00000075	0.000000075	0.000000075	£2
EHV Sub Cable	0.00000075	0.000000075	0.000000075	£2
132kV Sub Cable	0.00000075	0.000000075	0.000000075	£2
LV Circuit Breaker	0.00004916	0.000434412	0.000370311	£9,109
LV Pillar (ID)	0.00004916	0.000434412	0.000370311	£9,109
LV Pillar (OD at Substation)	0.00004916	0.000434412	0.000370311	£9,109
LV UGB & LV Pillar (OD not at Substation)	0.00005193	0.000458912	0.000391196	£9,622
LV Board (WM)	0.00004916	0.000434412	0.000370311	£9,109
LV Board (X-type Network) (WM)	0.00004916	0.000434412	0.000370311	£9,109
6.6/11kV CB (GM) Primary	0.000260274	0.000115	0.001960616	£23,502
6.6/11kV CB (GM) Secondary	0.0000260274	0.00023	0.000196062	£4,823
6.6/11kV Switch (GM)	0.0000260274	0.00023	0.000196062	£4,823
6.6/11kV RMU	0.0000260274	0.00023	0.000196062	£4,823
6.6/11kV X-type RMU	0.0000260274	0.00023	0.000196062	£4,823
20kV CB (GM) Primary	0.000260274	0.000115	0.001960616	£23,502
20kV CB (GM) Secondary	0.0000260274	0.00023	0.000196062	£4,823
20kV Switch (GM)	0.0000260274	0.00023	0.000196062	£4,823
20kV RMU	0.0000260274	0.00023	0.000196062	£4,823
33kV CB (Air Insulated Busbars)(ID)(GM)	0.000260274	0.000115	0.001960616	£23,502
33kV CB (Air Insulated Busbars)(OD)(GM)	0.000260274	0.000115	0.001960616	£23,502
33kV CB (Gas Insulated Busbars)(ID)(GM)	0.000260274	0.000115	0.001960616	£23,502
33kV CB (Gas Insulated Busbars)(OD)(GM)	0.000260274	0.000115	0.001960616	£23,502
33kV Switch (GM)	0.000260274	0.000115	0.001960616	£23,502
33kV RMU	0.000260274	0.000115	0.001960616	£23,502
66kV CB (Air Insulated Busbars)(ID)(GM)	0.000260274	0.000115	0.001960616	£23,502
66kV CB (Air Insulated Busbars)(OD)(GM)	0.000260274	0.000115	0.001960616	£23,502
66kV CB (Gas Insulated Busbars)(ID)(GM)	0.000260274	0.000115	0.001960616	£23,502
66kV CB (Gas Insulated Busbars)(OD)(GM)	0.000260274	0.000115	0.001960616	£23,502

Asset Register Category	PROBABILITY OF EVENT PER ASSET FAILURE			Reference Safety Cost of Failure*
	Lost Time Accident	Death or Serious Injury to public	Death or Serious Injury to staff	
132kV CB (Air Insulated Busbars)(ID)(GM)	0.000416438	0.0000575	0.003136986	£36,171
132kV CB (Air Insulated Busbars)(OD)(GM)	0.000416438	0.0000575	0.003136986	£36,171
132kV CB (Gas Insulated Busbars)(ID)(GM)	0.000416438	0.0000575	0.003136986	£36,171
132kV CB (Gas Insulated Busbars)(OD)(GM)	0.000416438	0.0000575	0.003136986	£36,171
6.6/11kV Transformer (GM)	0.0000260274	0.00023	0.000196062	£4,823
20kV Transformer (GM)	0.0000260274	0.00023	0.000196062	£4,823
33kV Transformer (GM)	0.000260274	0.000115	0.001960616	£23,502
66kV Transformer (GM)	0.000260274	0.000115	0.001960616	£23,502
132kV Transformer (GM)	0.000416438	0.0000575	0.003136986	£36,171

* - values rounded to nearest £ for presentation in this table

D.2.2 Safety Consequence Factors

As described in Section 7.4.3 the Safety CoF can then be derived for individual assets by the application of a Type Safety Factor and/or a Location Safety Factor so that it reflects the characteristics of an individual asset. These are detailed by Asset Category Grouping in Table 225 and Table 226. Where a Type or Location rating has not been determined, then the Medium (Default) rating shall be assumed.

D.2.2.1 SWITCHGEAR, TRANSFORMERS & OVERHEAD LINES

Under the Electricity Safety Quality and Continuity Regulations 2002 (ESQCR), risk assessments must be carried out on substation sites and overhead lines to assess the risk of interference, vandalism or unauthorised access to the asset by the public.

The overall risk value is built from the following components:-

- Type (Risk that the asset presents to the public by its characteristics and particular situation); and
- Location (Proximity to areas that may affect its likelihood of trespass or interference).

The overall Safety CoF Factors for Switchgear, Transformers and Overhead Lines are determined by these Type and Location Risk Ratings as shown in Table 225.

TABLE 225: SAFETY CONSEQUENCE FACTOR – SWITCHGEAR, TRANSFORMERS & OVERHEAD LINES

Safety Consequence Factor – Switchgear, Transformers & Overhead Lines		TYPE RISK RATING		
		Low	Medium (Default)	High
LOCATION RISK RATING	Low	0.7	0.9	1.2
	Medium (Default)	0.9	1	1.4
	High	1.2	1.4	1.6

D.2.2.3 CABLES

For cables there is a significant level of inherent safety of these asset types given the majority of the assets are buried. However, it is considered appropriate to modify the Reference Safety Cost of Failure to account for those situations where cables are exposed above ground, e.g. cable structures or where cables terminate onto overhead line supports.

The overall Safety CoF Factors for cable asset types are determined according to Table 226.

TABLE 226: SAFETY CONSEQUENCE FACTOR - CABLES

SAFETY CONSEQUENCE FACTOR - CABLES	
Buried	1.0
Exposed (e.g. cable structure)	2.0

D.2.3 Safety Risk Reduction Factor

As described in Section 7.4.3, a Safety Risk Reduction Factor is included in the derivation of Safety CoF. This is used to reflect the impact of measures that are taken to mitigate safety risks associated with individual assets. For LV UGB assets this applies to the mitigation of safety risks through the installation of safety protection blankets. The Safety Risk Reduction Factor is determined as shown in Table 227.

TABLE 227: SAFETY RISK REDUCTION FACTOR

SAFETY RISK REDUCTION FACTOR	
LV UGB with Safety Blanket	0.5
All other assets – including LV UGB without Safety Blanket, Switchgear, Transformers, Cables & Overhead Lines	1.0
Default (no data available)	1.0

D.3 Environmental

D.3.1 Reference Environmental Cost of Failure

The Environmental CoF value for an asset is derived using a Reference Environmental Cost of Failure, which is modified for individual assets using asset-specific factors. This is based on an assessment of the typical environmental impacts of a failure of the asset in each of its three failure modes; incipient, degraded and catastrophic. The Reference Environmental Cost of Failure that shall be used for each Asset Category is shown in Table 228.

This assessment considers four factors;

i) Volume of oil lost;
ii) Volume of SF_6 lost;
iii) Probability of the event leading to a fire; and
iv) Quantity of waste produced.

$$\begin{aligned}
&\textbf{Reference Environmental Cost of Failure} = (\textbf{\% of Incipient Failures}) \times \\
&((\textbf{Volume of oil lost per Incipient failure} \times \textbf{Environmental cost per litre oil (£/litre)}) + \\
&(\textbf{Volume of SF}_6 \textbf{ lost per Incipient failure} \times \textbf{Environmental cost per kg of SF}_6 \textbf{ lost (£/kg)}) + \\
&(\textbf{Probability of failure leading to a fire per Incipient failure} \times \textbf{Environmental cost of fire}) + \\
&(\textbf{Quantity of waste produced per incipient failure} \times \textbf{Environmental cost per tonne waste (£/t)})) + \\
&(\textbf{\% of Degraded Failures}) \times ((\textbf{Volume of oil lost per Degraded failure} \times \\
&\textbf{Environmental cost per litre oil (£/litre)}) + (\textbf{Volume of SF}_6 \textbf{ lost per Degraded failure} \times \\
&\textbf{Environmental cost per kg of SF}_6 \textbf{ lost (£/kg)}) + \\
&(\textbf{Probability of failure leading to a fire per Degraded failure} \times \textbf{Environmental cost of fire}) + \\
&(\textbf{Quantity of waste produced per Degraded failure} \times \textbf{Environmental cost per tonne waste (£/t)})) + \\
&(\textbf{\% of Catastrophic Failures}) \times ((\textbf{Volume of oil lost per Catastrophic failure} \times \\
&\textbf{Environmental cost per litre oil (£/litre)}) + (\textbf{Volume of SF}_6 \textbf{ lost per Catastrophic failure} \times \\
&\textbf{Environmental cost per kg of SF}_6 \textbf{ lost (£/kg)}) + \\
&(\textbf{Probability of failure leading to a fire per Catastrophic failure} \times \textbf{Environmental cost of fire}) + \\
&\textbf{Quantity of waste produced per Catastophic failure} \times \textbf{Environmental cost per tonne waste (£/t)})))
\end{aligned}$$

EQ. 32

Where:

- *Environmental cost per litre oil = £43.35/litre*
- *Environmental cost per kg of SF_6 lost = £1,723/kg*
  Which is derived from:
  - *Traded carbon price = £17.10/tonne*
  - *Cost of SF_6 loss c/w cost of carbon = 23,900kg(CO_2)/kg*
- *Environmental cost of fire = £6,007*
- *Environmental cost per tonne waste = £180/tonne*

The sources for the above costs are shown in Table 17 in Section 7.5.2.

The detailed breakdown of the Reference Environmental Cost of Failure by Asset Category is shown in Table 228.

TABLE 228: REFERENCE ENVIRONMENTAL COST OF FAILURE

Asset Register Category	Average volume of oil lost per failure (litres)			Average volume of SF6 lost per failure (kg)			Average probability that failure results in a fire			Average quantity of waste per failure (t)			Failures as % of all failures			Reference Environmental Consequence*
	I	D	C	I	D	C	I	D	C	I	D	C	I	D	C	
LV OHL Support	0	0	0	0	0	0	0	0	0.0005	0.5	0.5	0.5	49%	49%	2%	£90
HV OHL Support - Poles	0	0	0	0	0	0	0	0	0.0005	0.5	0.5	0.5	49%	49%	2%	£90
EHV OHL Support - Poles	0	0	0	0	0	0	0	0	0.0005	0.5	0.5	0.5	49%	49%	2%	£90
EHV UG Cable (Gas)	0	0	0	0	0	0	0	0	0.001	0.2	0.2	10	45%	54%	1%	£54
132kV UG Cable (Gas)	0	0	0	0	0	0	0	0	0.001	0.3	0.3	15	45%	54%	1%	£81
EHV UG Cable (Oil)	120	120	1200	0	0	0	0	0	0.001	0.8	0.8	40	45%	54%	1%	£5,885
132kV UG Cable (Oil)	150	150	1500	0	0	0	0	0	0.001	1.2	1.2	60	45%	54%	1%	£7,410
LV Switchgear and Other	0	0	0	0	0	0	0	0.0002	0.005	0.01	0.1	0.25	50%	30%	20%	£22
LV UGB	0	0	0	0	0	0	0	0.0002	0.05	0.01	0.1	0.5	50%	30%	20%	£85
HV Switchgear (GM) - Primary	10	50	150	0.1	0.2	0.5	0	0.0005	0.01	0.1	0.2	0.5	65%	30%	5%	£1,547
HV Switchgear (GM) - Distribution	10	50	150	0.1	0.1	0.4	0	0.0005	0.01	0.1	0.2	0.5	65%	30%	5%	£1,486
EHV Switchgear (GM)	25	125	250	0.4	1	3	0	0.0005	0.01	0.2	0.5	2	70%	20%	10%	£4,356
132kV Switchgear	50	250	1000	4	10	30	0	0.0005	0.01	0.3	2	10	70%	20%	10%	£21,756
HV Transformer (GM)	20	100	300	0	0	0	0.0002	0.002	0.02	1	2	5	50%	40%	10%	£3,809
EHV Transformer (GM)	50	250	2500	0	0	0	0.0002	0.002	0.02	0.2	3	30	50%	40%	10%	£17,048
132kV Transformer (GM)	100	500	5000	0	0	0	0.0002	0.002	0.02	0.5	10	100	50%	40%	10%	£35,095
EHV UG Cable (Non Pressurised)	0	0	0	0	0	0	0	0	0.001	0	0	4	0%	0%	100%	£726
132kV UG Cable (Non Pressurised)	0	0	0	0	0	0	0	0	0.001	0	0	6	0%	0%	100%	£1,086
Submarine Cables	0	0	0	0	0	0	0	0	0	0	0	20	0%	0%	100%	£3,600
EHV OHL Support - Towers	0	0	0	0	0	0	0	0	0.001	0	0	1	0%	0%	100%	£186
132kV OHL Support - Tower	0	0	0	0	0	0	0	0	0.001	0	0	1	0%	0%	100%	£186
EHV OHL Fittings	0	0	0	0	0	0	0	0	0.001	0	0	0.5	0%	0%	100%	£96
132kV OHL Fittings	0	0	0	0	0	0	0	0	0.001	0	0	0.5	0%	0%	100%	£96
EHV OHL Conductor (Tower Lines)	0	0	0	0	0	0	0	0	0.001	0	0	0.5	0%	0%	100%	£96
132kV OHL Conductor (Tower Lines)	0	0	0	0	0	0	0	0	0.001	0	0	0.5	0%	0%	100%	£96

* - values rounded to nearest £ for presentation in this table

D.3.2 Environmental Consequence Factors

As described in Section 7.5.3 the resulting Reference Environmental Cost of Failure can then be modified for individual assets within that type based on the application of a Type Environmental Factor, Size Environmental Factor and/or a Location Environmental Factor to result in an Environmental CoF that reflects the characteristics of an individual asset of that type. These are shown in Table 229 by Asset Category Grouping.

The Type Environmental Factor for switchgear shall consider whether the individual asset contains oil or SF_6, either as an interruption medium or insulation medium,

TABLE 229: TYPE ENVIRONMENTAL FACTOR

Type environment factor	Oil	SF_6	Neither	Default
HV Switchgear (GM) - Primary	0.97	0.05	0.02	0.97
HV Switchgear (GM) - Distribution	0.98	0.04	0.02	0.98
EHV Switchgear (GM)	0.93	0.10	0.03	0.93
132kV Switchgear	0.79	0.24	0.03	0.79

All other Asset Categories are set to a default Type Environmental Factor of 1.

TABLE 230: SIZE ENVIRONMENTAL FACTOR

Asset Category	Size Environmental Factor Criteria	Size Environmental Factor
6.6/11kV Transformer (GM)	≥750kVA	1
	≥500kVA and <750kVA	1
	<500kVA	0.6
20kV Transformer (GM)	≥750kVA	1
	≥500kVA and <750kVA	1
	<500kVA	0.6
33kV Transformer (GM)	33/20kV, >20MVA CMR equivalent	1.6
	33/20kV, >10MVA and ≤20MVA CMR equivalent	1
	33/20kV, ≤10MVA CMR equivalent	0.7
	33/11 or 6.6kV, >20MVA CMR equivalent	1.6
	33/11 or 6.6kV, >10MVA and ≤20MVA CMR equivalent	1
	33/11 or 6.6kV, ≤10MVA CMR equivalent	0.7
66kV Transformer (GM)	66/20kV, >20MVA CMR equivalent	1.6
	66/20kV, >10MVA and ≤20MVA CMR equivalent	1
	66/20kV, ≤10MVA CMR equivalent	0.7
	66/33kV	1.2
	66/11/11kV	1.2
	66/11 or 6.6kV, >20MVA CMR equivalent	1.6

Asset Category	Size Environmental Factor Criteria	Size Environmental Factor
66kV Transformer (GM)	66/11 or 6.6kV, >10MVA and ≤20MVA CMR equivalent	1
	66/11 or 6.6kV, ≤10MVA CMR equivalent	0.7
132kV Transformer (GM)	132/66kV, ≤60MVA	0.8
	132/66kV, >60MVA	1
	132/33kV, ≤60MVA	0.8
	132/33kV, >60MVA	1
	132/11/11kV	0.8
	132/11kV	0.7
	132/20kV	0.7
	132/20/20kV	0.8
132kV Switchgear	132kV CB (Air Insulated Busbars)(ID)(GM)	1
	132kV CB (Air Insulated Busbars)(OD)(GM)	1
	132kV CB (Gas Insulated Busbars)(ID)(GM)	2.5
	132kV CB (Gas Insulated Busbars)(OD)(GM)	2.5

The default value for Size Environmental Factor is 1. The default value shall be applied to all those Asset Categories that are not shown in Table 230.

TABLE 231: LOCATION ENVIRONMENTAL FACTOR

Asset Category	Proximity Factor				Bunding Factor	
	Not Close to Water Course (>120m) or No Oil	Moderately Close to Water Course (between 80m and 120m)	Close to Water Course (between 40m and 80m)	Very Close to Water Course (<40m)	Bunded	Not bunded
EHV UG Cable (Oil)	0.8	1	1.5	2.5	0.5	1
132kV UG Cable (Oil)	0.8	1	1.5	2.5	0.5	1
HV Switchgear (GM) - Primary	0.8	1	1.5	2.5	0.5	1
HV Switchgear (GM) - Distribution	0.8	1	1.5	2.5	0.5	1
EHV Switchgear (GM)	0.8	1	1.5	2.5	0.5	1
132kV Switchgear	0.8	1	1.5	2.5	0.5	1
HV Transformer (GM)	0.8	1	1.5	2.5	0.5	1
EHV Transformer (GM)	0.8	1	1.5	2.5	0.5	1
132kV Transformer (GM)	0.8	1	1.5	2.5	0.5	1

The default value for Location Environmental Factor is 1. The default value shall be applied to all those Asset Categories that are not shown in Table 231.

D.4 Network Performance

D.4.1 Reference Network Performance Cost of Failure (LV & HV)

The Reference Network Performance Cost of Failure is based on an assessment of the typical network costs incurred by a failure of the asset as measured through its impact in relation to the number of customers interrupted and the duration of those interruptions. For regulatory purposes, this is captured via the IIS mechanism.

TABLE 232: COSTS USED IN DERIVATION OF NETWORK PERFORMANCE REFERENCE COST OF FAILURE

Parameter	£ (at 2020/21 prices)
Cost of CML	£0.45*
Cost of CI	£18.55*

* *source: Ofgem RIIO-ED2 CBA template*

For each Asset Category, an assessment is made of:-

i) the typical number of customers interrupted by a failure; and
ii) the typical duration of any loss of supply to customers.

This assessment considers two time periods that reflect the initial fault impact and response activity and the subsequent time to fully restore supplies and restore the asset to its pre-fault state, as illustrated in Figure 28.

FIGURE 28: NETWORK PERFORMANCE - LV & HV

This considers:-

i) the proportion of failures that result in an interruption to supply. This is taken as being the proportion of total failures that are Degraded Failures or Catastrophic Failures. It is assumed that remedial works to address Incipient Failures can be undertaken as planned works and therefore that mitigation measures would be employed to avoid any Network Performance impact;
ii) the typical number of customers connected to the section of distribution network that is affected by failure of the asset (the Reference Number of Connected Customers);

iii) the typical number of customers whose supply is restored through immediate switching. This is expressed as a proportion of the Reference Number of Connected Customers. A customer's supply is only considered as being interrupted where supply is not restored immediately, which is consistent with the IIS mechanism;
iv) the typical time to restore further supplies through manual switching;
v) the typical number of customers whose supplies are restored following completion of manual switching. This is expressed as a proportion of the Reference Number of connected Customers (and represents the total number of customers whose supplies are restored by immediate switching or manual switching); and
vi) the typical time to repair the failure (and restore any remaining supplies that were not restored by manual switching).

In evaluating the Reference Network Performance Cost of Failure:-
i) the number of customers interrupted per failure is multiplied by the relevant cost of a customer interruption (Cost of CI); and
ii) the number of customer minutes without supply per failure is evaluated; and multiplied by the relevant cost of a customer minute lost (Cost of CML)

to produce a cost per failure for a given Reference Number of Connected Customers. This is shown in EQ. 36.

$$\begin{aligned}&\textbf{Reference Network Performance Cost of Failure} = \\ &[(\textbf{Cost of CML} \times \textbf{60} \times \textbf{Reference Number of CC} \times \textbf{Switching Time} \times (\textbf{100\%} \\ &\qquad - \textbf{\% of CC restored through immediate switching})) \\ &+ (\textbf{Cost of CML} \times \textbf{60} \times \textbf{Reference Number of CC} \times \textbf{Restoration Time} \times (\textbf{100\%} - \\ &\textbf{\% of CC restored after manual switching})) \\ &+ (\textbf{Cost of CI} \times \textbf{Reference Number of CC} \times (\textbf{100\%} - \\ &\textbf{\% of CC restored through immediate switching}))] \times \textbf{\% of failures that result in} \\ &\textbf{interruption to supply}\end{aligned}$$

EQ. 36

Where:
- *CC = Connected Customers*
- *Switching Time and Restoration Time are durations (in hours)*

Table 233 summarises the parameters used in evaluating the Reference Network Performance Cost of Failure for each HV and LV Asset Category.

TABLE 233: REFERENCE NETWORK PERFORMANCE COST OF FAILURE FOR LV & HV ASSETS

Asset Category	Reference Number of Connected Customers	Proportion of connected customers restored through immediate (< 3min) switching	Proportion of customers restored After manual switching	Manual switching time (hours)	Typical repair time (hours)	Proportion of failures that result in interruption to supply	Reference Network Performance Cost (£)*
LV OHL Support	30	0%	0%	1	5	10%	£542
HV OHL Support - Poles	1000	60%	94%	0.5	4	10%	£1,930
HV Transformer (GM)	150	0%	85%	0.5	4	60%	£4,343
HV Switchgear (GM) - Distribution	1000	60%	94%	0.5	4	60%	£11,580
HV Switchgear (GM) - Primary	3500	60%	94%	0.5	4	60%	£40,530
LV Circuit Breaker	150	0%	85%	1	7	100%	£11,085
LV Pillar	150	25%	89%	1	7	100%	£8,243
LV UGB	50	25%	89%	1	7	100%	£2,748
LV Board (WM)	150	25%	89%	1	7	100%	£8,243
HV Sub Cable	800	40%	60%	2	18	100%	£190,344

* - values rounded to nearest £ for presentation in this table

D.4.2 Network Performance Factors (LV & HV)

As described in Section 7.6.2.2 the Reference Network Performance Cost of Failure can then be modified on an asset by asset basis as shown in EQ. 37.

$$\text{Network Performance Cost of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Network Performance Consequence Factor}$$

EQ. 37

Where:

$$\text{Network Performance Consequence Factor} = \text{Customer Factor} \times \text{Customer Sensitivity Factor}$$

EQ. 38

Customer Factor

This Factor is used to reflect the number of customers impacted by failure of an individual asset, relative to the reference number of customers used in the derivation of the Reference Network Performance Cost of Failure.

This is applied as a direct Factor, i.e. not via a lookup table. For example, if the number of customers used in the derivation of the Reference Network Performance Cost of Failure is 100, but for a specific example it is 80 (or 120), then a modifying factor of 0.8 (or 1.2) would be applied.

$$\text{Customer Factor} = \frac{\text{No. of Customers}}{\text{Reference No. of Customers}}$$

EQ. 39

Where a DNO identifies that the customers fed by an individual asset have an exceptionally high demand per customer, then the No. of Customers used in the derivation of EQ. 39 may be derived by applying an adjustment to the actual number of customers fed by the asset as shown in Table 234 which is a repeat of Table 18. This adjustment recognises that for high demand customers the cost of a customer interruption and a customer minute lost may not reflect the value of lost load to the customer. DNOs can elect whether or not to apply this adjustment within their implementation of the Methodology.

TABLE 234 (TABLE: 18 REPEATED): CUSTOMER NUMBER ADJUSTMENT FOR LV & HV ASSETS WITH HIGH DEMAND CUSTOMERS

Maximum Demand on Asset / Total Number of Customers fed by the Asset (kVA per Customer)	No. of Customers to be used in the derivation of Customer Factor
< 50	1 x actual number of customers fed by the asset
≥ 50 and < 100	25 x actual number of customers fed by the asset
≥ 100 and < 500	100 x actual number of customers fed by the asset
≥ 500 and < 1000	250 x actual number of customers fed by the asset
≥ 1000 and < 2000	500 x actual number of customers fed by the asset
≥ 2000	1000 x actual number of customers fed by the asset

The default value for the Customer Factor is 1.

Customer Sensitivity Factor

The Customer Sensitivity Factor is used to reflect circumstances where the customer impact is increased due to customer reliance on electricity (e.g. vulnerable customers). DNOs may use this factor at their discretion in order to modify the Network Performance Consequence Factor.

The default value for the Customer Sensitivity Factor is 1. Individual DNOs are provided with the freedom within the Methodology to apply a Customer Sensitivity Factor, other than the default, to the Network Performance Consequences (LV & HV) for any asset, provided that:-

i) the individual DNO documents all instances where a Customer Sensitivity Factor different from the default is applied within their individual Network Asset Indices Methodology; and
ii) The Customer Sensitivity Factor shall not be less than 1, nor greater than 2.

D.4.3 Reference Network Performance Cost of Failure (EHV & 132kV)

For EHV and 132kV assets the Reference Network Performance Cost of Failure is based on an assessment of the amount of Load at Risk during three stages of failure, and the typical duration of each stage:-

i) During fault (T1): this is the time period between initial circuit protection trip operation and automatic switching to reconfigure the network;
ii) During initial switching (T2): this is the time period during which further manual network switching is undertaken to reconfigure the network to minimise the risk associated with a further circuit outage; and
iii) During repair time (T3).

These three stages are illustrated in Figure 29.

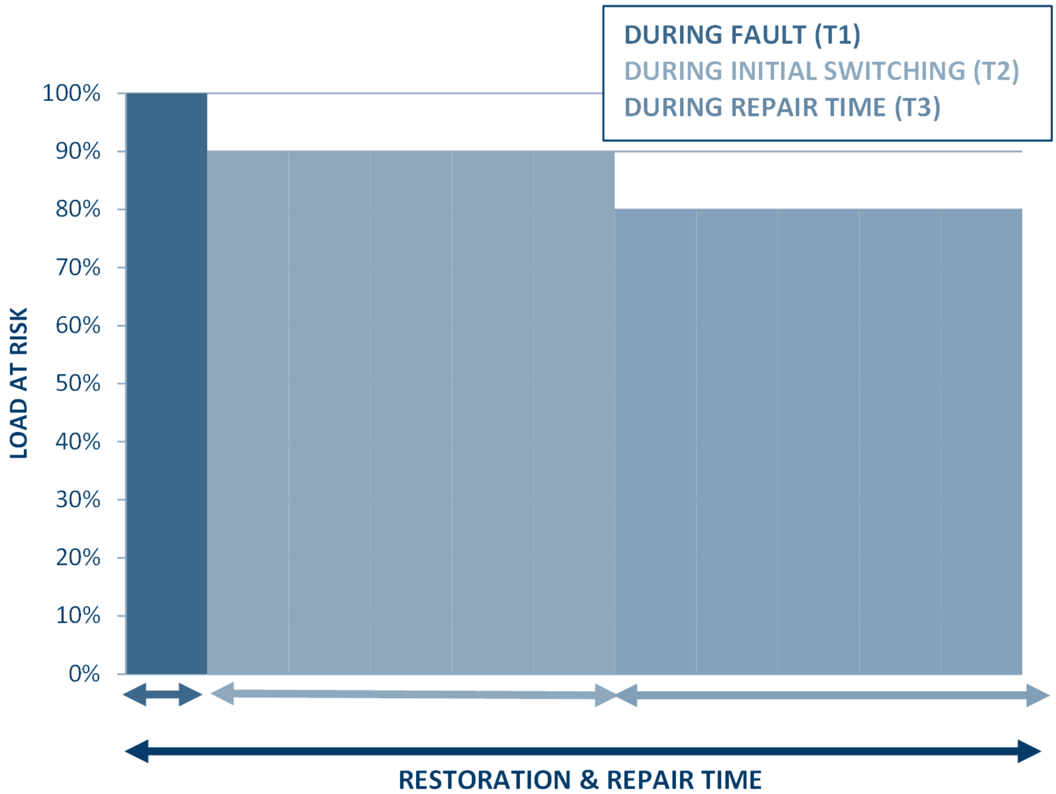

FIGURE 29: REFERENCE NETWORK PERFORMANCE COST OF FAILURE (EHV & 132KV)

The Load at Risk during each stage represents the amount of load that would experience a loss of supply if a further circuit outage were to occur. The probability of the occurrence of such a further coincident outage is considered in the derivation of the Reference Network Performance Cost of Failure.

The proportion of failures that result in an unplanned outage is also considered. This is taken as being the proportion of total failures that are Degraded Failures or Catastrophic Failures. It is assumed that remedial works to address Incipient Failures can be undertaken as planned works and therefore can be scheduled, or mitigation measures employed, to avoid any Network Performance impact of a coincident outage.

The Load at risk, duration, probability of a further coincident outage and proportion of failures resulting in an unplanned outage are used to derive the probable amount of load lost (in MVAh) per failure. The relevant Value of Lost Load (VoLL) is then used to derive a typical Reference Network Performance Cost of Failure for these assets.

$$\textbf{Reference Network Performance Cost of Failure} = \Big(\big(\textbf{Load at risk in T1} \times \textbf{Duration of T1}\big) + \big(\textbf{Load at risk in T2} \times \textbf{Duration of T2}\big) + \big(\textbf{Load at risk in T3} \times \textbf{Duration of T3}\big)\Big) \times \textbf{\% of failures that result in an unplanned outage} \times \textbf{Probability of further coincident outage} \times \textbf{VoLL}$$

EQ. 40

The value of VoLL adopted in this instance is £21,788 (Para 7.36 of Ofgem's document titled "RIIO-ED2 Methodology Decision: Annex 1 - Delivering value for money services for consumers" (17th December 2020) states a decision to set VoLL at £21,000 (at 2018/19 prices) for use in setting IIS incentive rates in RIIO-ED2. This has been inflated to 2020/21 prices).

Typical values of Load at Risk have been used, for each Asset Category in deriving the Reference Network Performance Cost of Failure. These are based on consideration of:-

- typical values for the maximum demand that would normally be supplied from the affected section of network; and
- the proportion of the maximum demand that would be at risk of loss of supply, should a further coincident outage occur, during each stage (i.e. periods T1, T2 and T3)

such that:

$$\begin{aligned}\text{Load at risk in T1} &= \text{Maximum Demand} * \%\text{ of maximum demand at risk during T1};\\ \text{Load at risk in T2} &= \text{Maximum Demand} * \%\text{ of maximum demand at risk during T2};\\ \text{Load at risk in T3} &= \text{Maximum Demand} * \%\text{ of maximum demand at risk during T3}\end{aligned}$$

EQ. 43

In this way, the Reference Network Performance Cost of Failure represents costs associated with a given level of maximum demand. This is representative of networks that are secure for a first circuit outage.

For linear assets (Cables and OHL), the maximum demand that is used to derive the reference costs is determined by applying a likely utilisation to a typical circuit rating for circuits of that voltage.

For discrete plant assets, the load at risk is more quantifiable and therefore the maximum demand that is used to derive the reference costs is based on the rating of the asset (in the case of transformers) or the board at the substation in the case of switchgear (it is assumed half of the switchboard would be out of commission for the catastrophic failure of a circuit breaker).

Table 235 shows the values of Reference Network Performance Cost of Failure that shall be used for EHV and 132kV assets. This table also shows the maximum demand used to derive these reference costs. The Load Factor that is applied in the calculation of Network Performance Consequences shall be calculated using these maximum demand values.

TABLE 235: REFERENCE NETWORK PERFORMANCE COST OF FAILURE FOR EHV & 132KV ASSETS (SECURE)

Asset Category	Maximum Demand Used to Derive Reference Cost (MVA)	Load at Risk (MVA) as % of Maximum Demand			Time (hours)			Probability of a coincident fault per hr	Proportion of failures that result in an unplanned outage	Reference Cost for Assets in Secure Networks (£)*
		During T1 period	During T2 period	During T3 period	T1	T2	T3			
33kV Pole	12	100%	100%	80%	0	3	5	0.05%	10%	£92
66kV Pole	24	100%	100%	80%	0	3	5	0.05%	10%	£183
33kV Tower	12	100%	100%	80%	0	3	24	0.05%	20%	£580
66kV Tower	24	100%	100%	80%	0	3	36	0.05%	20%	£1,663
132kV Tower	60	100%	100%	80%	0	3	36	0.05%	20%	£4,157
33kV Fittings	12	100%	100%	80%	0	3	9	0.05%	20%	£267
66kV Fittings	24	100%	100%	80%	0	3	9	0.05%	20%	£533
132kV Fittings	60	100%	100%	80%	0	3	9	0.05%	20%	£1,333
33kV OHL (Tower Line) Conductor	12	100%	100%	80%	0	3	9	0.05%	100%	£1,333
66kV OHL Conductor	24	100%	100%	80%	0	3	9	0.05%	100%	£2,667
132kV OHL (Tower Line) Conductor	60	100%	100%	80%	0	3	9	0.05%	100%	£6,667
33kV UG Cable (Non Pressurised)	12	100%	100%	80%	0	3	30	0.05%	100%	£3,530
33kV UG Cable (Oil)	12	100%	100%	80%	0	3	30	0.05%	0.10%	£4
33kV UG Cable (Gas)	12	100%	100%	80%	0	3	30	0.05%	1%	£35
66kV UG Cable (Non Pressurised)	24	100%	100%	80%	0	3	30	0.05%	100%	£7,059
66kV UG Cable (Oil)	24	100%	100%	80%	0	3	30	0.05%	0.10%	£7
66kV UG Cable (Gas)	24	100%	100%	80%	0	3	30	0.05%	1%	£71
132kV UG Cable (Non Pressurised)	60	100%	100%	80%	0	3	30	0.05%	100%	£17,648
132kV UG Cable (Oil)	60	100%	100%	80%	0	3	30	0.05%	0.10%	£18
132kV UG Cable (Gas)	60	100%	100%	80%	0	3	30	0.05%	1%	£176
EHV Sub Cable	12	100%	100%	80%	0	3	30	0.05%	100%	£3,530
132kV Sub Cable	60	100%	100%	80%	0	3	30	0.05%	100%	£17,648

Asset Category	Maximum Demand Used to Derive Reference Cost (MVA)	Load at Risk (MVA) as % of Maximum Demand			Time (hours)			Probability of a coincident fault per hr	Proportion of failures that result in an unplanned outage	Reference Cost for Assets in Secure Networks (£)*
		During T1 period	During T2 period	During T3 period	T1	T2	T3			
33kV CB (Air Insulated Busbars)(ID)(GM)	30	100%	100%	80%	0	2	200	0.05%	55%	£29,120
33kV CB (Air Insulated Busbars)(OD)(GM)	30	100%	100%	80%	0	2	100	0.05%	55%	£14,740
33kV CB (Gas Insulated Busbars)(ID)(GM)	30	100%	100%	80%	0	2	200	0.05%	55%	£29,120
33kV CB (Gas Insulated Busbars)(OD)(GM)	30	100%	100%	80%	0	2	100	0.05%	55%	£14,740
33kV Switch (GM)	30	100%	100%	80%	0	2	100	0.05%	55%	£14,740
33kV RMU	30	100%	100%	80%	0	2	100	0.05%	55%	£14,740
66kV CB (Air Insulated Busbars)(ID)(GM)	30	100%	100%	80%	0	2	200	0.05%	55%	£29,120
66kV CB (Air Insulated Busbars)(OD)(GM)	30	100%	100%	80%	0	2	100	0.05%	55%	£14,740
66kV CB (Gas Insulated Busbars)(ID)(GM)	30	100%	100%	80%	0	2	200	0.05%	55%	£29,120
66kV CB (Gas Insulated Busbars)(OD)(GM)	30	100%	100%	80%	0	2	100	0.05%	55%	£14,740
132kV CB (Air Insulated Busbars)(ID)(GM)	80	100%	100%	80%	0	1	400	0.05%	55%	£153,867
132kV CB (Air Insulated Busbars)(OD)(GM)	80	100%	100%	80%	0	1	100	0.05%	55%	£38,826
132kV CB (Gas Insulated Busbars)(ID)(GM)	80	100%	100%	80%	0	1	400	0.05%	55%	£153,867
132kV CB (Gas Insulated Busbars)(OD)(GM)	80	100%	100%	80%	0	1	100	0.05%	55%	£38,826
33kV Transformer (GM)	15	100%	100%	80%	0	2	400	0.05%	55%	£28,940
66kV Transformer (GM)	15	100%	100%	80%	0	2	400	0.05%	55%	£28,940
132kV Transformer (GM)	60	100%	100%	80%	0	1	800	0.05%	55%	£230,441

* - values rounded to nearest £ for presentation in this table

D.4.4 Network Performance Factors (EHV & 132kV)

As described in Section 7.6.3.2 the Network Performance CoF is derived on an asset by asset basis as shown in EQ. 41.

$$\text{Network Performance Consequences of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Load Factor} \times \text{Network Type Factor}$$

EQ. 41

Load Factor

This Factor allows for the Network Performance CoF to reflect the actual load at risk associated with the failure of the asset under consideration, relative to the value of maximum demand used to create the reference value.

The Load Factor is determined as shown in EQ. 42 (i.e. not via a lookup table).

$$\text{Load Factor} = \frac{\text{Actual Load at Risk Associated with the Failure of the Asset Under Consideration}}{\text{Maximum Demand Used To Derive Reference Network Performance Cost of Failure}}$$

EQ. 42

For example, if the Reference Network Performance Cost of Failure has been derived using a reference maximum demand of 12MVA, but for a specific asset the actual load at risk was 6MVA then a Load Factor of 0.5 would be applied.

The values of maximum demand used in derivation of the Reference Network Performance Cost of Failure can be found in Table 235 in Appendix D.

Where the actual load is not known, the default value for Load Factor is dependent on the security of supply of the associated network.

A default Load Factor of 0.5 shall be applied where an individual asset is located in a network that is not secure for a first circuit outage event that would result from failure of the asset (i.e. the network would be considered not secure if the load normally supplied by the asset would be interrupted and not restored automatically, in such an event).

A default Load Factor of 1 shall apply to assets in secure networks or where the security of the network is unknown.

Network Type Factor

This Network Performance CoF is derived on an asset by asset basis by the application of a Network Type Factor to take account of the security of supply afforded by the topology of the network in which the individual asset is located.

A Network Type Factor of 2.5 shall be applied where an individual asset is located in a network that is not secure for a first circuit outage event that would result from failure of the asset (i.e. the network would be considered not secure if the load normally supplied by the asset would be interrupted and not restored automatically, in such an event).

A Network Type Factor of 1 shall apply to assets in secure networks.

The default value for Network Type Factor is 1.

APPENDIX E
WEIGHTING FACTORS FOR APPLICATION TO RISK MATRICES

E.1 Typical Weighting Factors for Criticality Index Bands

TABLE 236: TYPICAL COF WEIGHTINGS FOR CRITICALITY INDEX BANDS FOR USE WITH RISK MATRICES

Asset Register Category	Typical COF Weightings for Each Criticality Index Band (£ at 20/21 prices)			
	C1	C2	C3	C4
LV Poles	1798.78	2569.68	3854.53	6424.21
LV Circuit Breaker	16999.67	24285.24	36427.86	60713.1
LV Pillar (ID)	16129.41	23042.02	34563.02	57605.04
LV Pillar (OD at Substation)	16480.36	23543.37	35315.05	58858.42
LV Pillar (OD not at a Substation)	14921.01	21315.73	31973.6	53289.33
LV Board (WM)	17644.46	25206.37	37809.55	63015.92
LV UGB	11118.48	15883.55	23825.32	39708.86
LV Board (X-type Network) (WM)	18632.02	26617.17	39925.75	66542.92
6.6/11kV Poles	2893.28	4133.25	6199.88	10333.13
20kV Poles	3160.82	4515.45	6773.18	11288.63
HV Sub Cable	263159.22	375941.74	563912.61	939854.35
6.6/11kV CB (GM) Primary	51215.17	73164.53	109746.8	182911.33
6.6/11kV CB (GM) Secondary	17393.48	24847.83	37271.74	62119.57
6.6/11kV Switch (GM)	16209.05	23155.78	34733.67	57889.45
6.6/11kV RMU	19409.55	27727.93	41591.89	69319.82
6.6/11kV X-type RMU	21842.3	31203.28	46804.92	78008.2
20kV CB (GM) Primary	52557.6	75082.28	112623.43	187705.71
20kV CB (GM) Secondary	17571.91	25102.73	37654.09	62756.82
20kV Switch (GM)	16795.26	23993.23	35989.84	59983.07
20kV RMU	19538.7	27912.43	41868.64	69781.07
6.6/11kV Transformer (GM)	15589.91	22271.3	33406.95	55678.25
20kV Transformer (GM)	16491.93	23559.9	35339.85	58899.75
33kV Pole	1993.15	2847.36	4271.04	7118.4
66kV Pole	2933.75	4191.07	6286.61	10477.68
33kV OHL (Tower Line) Conductor	14511.55	20730.79	31096.18	51826.97
33kV Tower	5525.07	7892.96	11839.43	19732.39
33kV Fittings	1468.88	2098.4	3147.6	5246
66kV OHL (Tower Line) Conductor	19509.99	27871.41	41807.12	69678.54
66kV Tower	10410.78	14872.54	22308.81	37181.36
66kV Fittings	1700.64	2429.48	3644.22	6073.71
33kV UG Cable (Non Pressurised)	25130.98	35901.4	53852.1	89753.51
33kV UG Cable (Oil)	4213.41	6019.15	9028.73	15047.89
33kV UG Cable (Gas)	285.12	407.31	610.97	1018.28
66kV UG Cable (Non Pressurised)	50265.64	71808.06	107712.09	179520.15
66kV UG Cable (Oil)	4223.24	6033.21	9049.81	15083.02
66kV UG Cable (Gas)	451.48	644.97	967.45	1612.42
EHV Sub Cable	204717.38	292453.4	438680.09	731133.49
33kV CB (Air Insulated Busbars)(ID)(GM)	50043.29	71490.41	107235.62	178726.04
33kV CB (Air Insulated Busbars)(OD)(GM)	42326.71	60466.73	90700.1	151166.84
33kV CB (Gas Insulated Busbars)(ID)(GM)	55272.53	78960.76	118441.15	197401.91
33kV CB (Gas Insulated Busbars)(OD)(GM)	45206.48	64580.68	96871.03	161451.71
33kV Switch (GM)	36997.86	52854.08	79281.13	132135.21
33kV RMU	47561	67944.28	101916.43	169860.71
66kV CB (Air Insulated Busbars)(ID)(GM)	60135.01	85907.16	128860.75	214767.91
66kV CB (Air Insulated Busbars)(OD)(GM)	62194.5	88849.28	133273.93	222123.21
66kV CB (Gas Insulated Busbars)(ID)(GM)	76407.14	109153.06	163729.6	272882.66
66kV CB (Gas Insulated Busbars)(OD)(GM)	66341.09	94772.98	142159.48	236932.46
33kV Transformer (GM)	110031.29	157187.56	235781.34	392968.9
66kV Transformer (GM)	142999.65	204285.21	306427.82	510713.03
132kV OHL (Tower Line) Conductor	20075.71	28679.59	43019.39	71698.98
132kV Tower	13540.32	19343.32	29014.98	48358.3
132kV Fittings	2396.27	3423.24	5134.86	8558.1
132kV UG Cable (Non Pressurised)	89586.02	127980.03	191970.04	319950.07

Asset Register Category	Typical COF Weightings for Each Criticality Index Band (£ at 20/21 prices)			
	C1	C2	C3	C4
132kV UG Cable (Oil)	5308.32	7583.32	11374.98	18958.29
132kV UG Cable (Gas)	742.22	1060.31	1590.47	2650.78
132kV Sub Cable	351254.41	501792.02	752688.03	1254480.05
132kV CB (Air Insulated Busbars)(ID)(GM)	205020.01	292885.73	439328.6	732214.33
132kV CB (Air Insulated Busbars)(OD)(GM)	94453.62	134933.74	202400.61	337334.36
132kV CB (Gas Insulated Busbars)(ID)(GM)	266480.05	380685.78	571028.67	951714.46
132kV CB (Gas Insulated Busbars)(OD)(GM)	185951.6	265645.14	398467.71	664112.86
132kV Transformer (GM)	395305.03	564721.47	847082.21	1411803.68

E.2 Weighting Factors for Determination of In-Year Risk

TABLE 237: TYPICAL POF WEIGHTINGS FOR HEALTH INDICES BANDS FOR USE IN THE CALCULATION OF IN-YEAR RISK FROM RISK MATRICES

Asset Register Category	Typical In-Year POF Weightings for Each Health Index Band				
	H1	H2	H3	H4	H5
LV Poles	0.008123	0.009326	0.021383	0.03463	0.061186
LV Circuit Breaker	0.001169	0.001342	0.003076	0.004982	0.008802
LV Pillar (ID)	0.001311	0.001505	0.003451	0.005589	0.009876
LV Pillar (OD at Substation)	0.001311	0.001505	0.003451	0.005589	0.009876
LV Pillar (OD not at a Substation)	0.001311	0.001505	0.003451	0.005589	0.009876
LV Board (WM)	0.001967	0.002258	0.005177	0.008384	0.014813
LV UGB	0.002195	0.00252	0.005777	0.009356	0.016531
LV Board (X-type Network) (WM)	0.001967	0.002258	0.005177	0.008384	0.014813
6.6/11kV Poles	0.008123	0.009326	0.021383	0.03463	0.061186
20kV Poles	0.008123	0.009326	0.021383	0.03463	0.061186
HV Sub Cable	0.005757	0.00661	0.015156	0.024545	0.043367
6.6/11kV CB (GM) Primary	0.001482	0.001702	0.003901	0.006318	0.011164
6.6/11kV CB (GM) Secondary	0.00191	0.002192	0.005027	0.008141	0.014384
6.6/11kV Switch (GM)	0.00191	0.002192	0.005027	0.008141	0.014384
6.6/11kV RMU	0.00191	0.002192	0.005027	0.008141	0.014384
6.6/11kV X-type RMU	0.00191	0.002192	0.005027	0.008141	0.014384
20kV CB (GM) Primary	0.001482	0.001702	0.003901	0.006318	0.011164
20kV CB (GM) Secondary	0.00191	0.002192	0.005027	0.008141	0.014384
20kV Switch (GM)	0.00191	0.002192	0.005027	0.008141	0.014384
20kV RMU	0.00191	0.002192	0.005027	0.008141	0.014384
6.6/11kV Transformer (GM)	0.002223	0.002552	0.005852	0.009478	0.016746
20kV Transformer (GM)	0.002223	0.002552	0.005852	0.009478	0.016746
33kV Pole	0.008123	0.009326	0.021383	0.03463	0.061186
66kV Pole	0.008123	0.009326	0.021383	0.03463	0.061186
33kV OHL (Tower Line) Conductor	0.00228	0.002618	0.006002	0.009721	0.017175
33kV Tower	0.015533	0.017834	0.04089	0.066222	0.117004
33kV Fittings	0.002736	0.003141	0.007203	0.011665	0.02061
66kV OHL (Tower Line) Conductor	0.00228	0.002618	0.006002	0.009721	0.017175
66kV Tower	0.015533	0.017834	0.04089	0.066222	0.117004
66kV Fittings	0.002736	0.003141	0.007203	0.011665	0.02061
33kV UG Cable (Non Pressurised)	0.018753	0.021532	0.049368	0.079952	0.141264
33kV UG Cable (Oil)	0.596913	0.685357	1.571374	2.544859	4.496404
33kV UG Cable (Gas)	1.283546	1.473727	3.378934	5.472225	9.668642
66kV UG Cable (Non Pressurised)	0.018753	0.021532	0.049368	0.079952	0.141264
66kV UG Cable (Oil)	0.596913	0.685357	1.571374	2.544859	4.496404
66kV UG Cable (Gas)	1.283546	1.473727	3.378934	5.472225	9.668642
EHV Sub Cable	0.005757	0.00661	0.015156	0.024545	0.043367
33kV CB (Air Insulated Busbars)(ID)(GM)	0.006356	0.007297	0.016731	0.027096	0.047875
33kV CB (Air Insulated Busbars)(OD)(GM)	0.006356	0.007297	0.016731	0.027096	0.047875
33kV CB (Gas Insulated Busbars)(ID)(GM)	0.006356	0.007297	0.016731	0.027096	0.047875

Asset Register Category	Typical In-Year POF Weightings for Each Health Index Band				
	H1	H2	H3	H4	H5
33kV CB (Gas Insulated Busbars)(OD)(GM)	0.006356	0.007297	0.016731	0.027096	0.047875
33kV Switch (GM)	0.006356	0.007297	0.016731	0.027096	0.047875
33kV RMU	0.006356	0.007297	0.016731	0.027096	0.047875
66kV CB (Air Insulated Busbars)(ID)(GM)	0.014592	0.016754	0.038414	0.062212	0.10992
66kV CB (Air Insulated Busbars)(OD)(GM)	0.014592	0.016754	0.038414	0.062212	0.10992
66kV CB (Gas Insulated Busbars)(ID)(GM)	0.014592	0.016754	0.038414	0.062212	0.10992
66kV CB (Gas Insulated Busbars)(OD)(GM)	0.014592	0.016754	0.038414	0.062212	0.10992
33kV Transformer (GM)	0.012939	0.014856	0.034062	0.055165	0.097468
66kV Transformer (GM)	0.012939	0.014856	0.034062	0.055165	0.097468
132kV OHL (Tower Line) Conductor	0.00228	0.002618	0.006002	0.009721	0.017175
132kV Tower	0.015533	0.017834	0.04089	0.066222	0.117004
132kV Fittings	0.002736	0.003141	0.007203	0.011665	0.02061
132kV UG Cable (Non Pressurised)	0.018753	0.021532	0.049368	0.079952	0.141264
132kV UG Cable (Oil)	0.596913	0.685357	1.571374	2.544859	4.496404
132kV UG Cable (Gas)	1.283546	1.473727	3.378934	5.472225	9.668642
132kV Sub Cable	0.005757	0.00661	0.015156	0.024545	0.043367
132kV CB (Air Insulated Busbars)(ID)(GM)	0.012284	0.014104	0.032337	0.05237	0.09253
132kV CB (Air Insulated Busbars)(OD)(GM)	0.012284	0.014104	0.032337	0.05237	0.09253
132kV CB (Gas Insulated Busbars)(ID)(GM)	0.012284	0.014104	0.032337	0.05237	0.09253
132kV CB (Gas Insulated Busbars)(OD)(GM)	0.012284	0.014104	0.032337	0.05237	0.09253
132kV Transformer (GM)	0.012939	0.014856	0.034062	0.055165	0.097468

TABLE 238: RISK MATRIX WEIGHTINGS - MONETISED IN-YEAR RISK

Asset Register Category	Criticality Index Band	In Year Monetised Risk Weighting (£ at 2020/21 prices) For Each Health Index Band				
		H1	H2	H3	H4	H5
LV Poles	C1	15	17	38	62	110
	C2	21	24	55	89	157
	C3	31	36	82	133	236
	C4	52	60	137	222	393
LV Circuit Breaker	C1	20	23	52	85	150
	C2	28	33	75	121	214
	C3	43	49	112	181	321
	C4	71	81	187	302	534
LV Pillar (ID)	C1	21	24	56	90	159
	C2	30	35	80	129	228
	C3	45	52	119	193	341
	C4	76	87	199	322	569
LV Pillar (OD at Substation)	C1	22	25	57	92	163
	C2	31	35	81	132	233
	C3	46	53	122	197	349
	C4	77	89	203	329	581
LV Pillar (OD not at a Substation)	C1	20	22	51	83	147
	C2	28	32	74	119	211
	C3	42	48	110	179	316
	C4	70	80	184	298	526
LV Board (WM)	C1	35	40	91	148	261
	C2	50	57	130	211	373
	C3	74	85	196	317	560
	C4	124	142	326	528	933
LV UGB	C1	24	28	64	104	184
	C2	35	40	92	149	263
	C3	52	60	138	223	394
	C4	87	100	229	372	656
LV Board (X-type Network) (WM)	C1	37	42	96	156	276
	C2	52	60	138	223	394
	C3	79	90	207	335	591
	C4	131	150	344	558	986

Asset Register Category	Criticality Index Band	In Year Monetised Risk Weighting (£ at 2020/21 prices) For Each Health Index Band				
		H1	H2	H3	H4	H5
6.6/11kV Poles	C1	24	27	62	100	177
	C2	34	39	88	143	253
	C3	50	58	133	215	379
	C4	84	96	221	358	632
20kV Poles	C1	26	29	68	109	193
	C2	37	42	97	156	276
	C3	55	63	145	235	414
	C4	92	105	241	391	691
HV Sub Cable	C1	1515	1739	3988	6459	11412
	C2	2164	2485	5698	9227	16303
	C3	3246	3727	8547	13841	24455
	C4	5411	6212	14244	23069	40759
6.6/11kV CB (GM) Primary	C1	76	87	200	324	572
	C2	108	125	285	462	817
	C3	163	187	428	693	1225
	C4	271	311	714	1156	2042
6.6/11kV CB (GM) Secondary	C1	33	38	87	142	250
	C2	47	54	125	202	357
	C3	71	82	187	303	536
	C4	119	136	312	506	894
6.6/11kV Switch (GM)	C1	31	36	81	132	233
	C2	44	51	116	189	333
	C3	66	76	175	283	500
	C4	111	127	291	471	833
6.6/11kV RMU	C1	37	43	98	158	279
	C2	53	61	139	226	399
	C3	79	91	209	339	598
	C4	132	152	348	564	997
6.6/11kV X-type RMU	C1	42	48	110	178	314
	C2	60	68	157	254	449
	C3	89	103	235	381	673
	C4	149	171	392	635	1122
20kV CB (GM) Primary	C1	78	89	205	332	587
	C2	111	128	293	474	838
	C3	167	192	439	712	1257
	C4	278	319	732	1186	2096
20kV CB (GM) Secondary	C1	34	39	88	143	253
	C2	48	55	126	204	361
	C3	72	83	189	307	542
	C4	120	138	315	511	903
20kV Switch (GM)	C1	32	37	84	137	242
	C2	46	53	121	195	345
	C3	69	79	181	293	518
	C4	115	131	302	488	863
20kV RMU	C1	37	43	98	159	281
	C2	53	61	140	227	401
	C3	80	92	210	341	602
	C4	133	153	351	568	1004
6.6/11kV Transformer (GM)	C1	35	40	91	148	261
	C2	50	57	130	211	373
	C3	74	85	195	317	559
	C4	124	142	326	528	932
20kV Transformer (GM)	C1	37	42	97	156	276
	C2	52	60	138	223	395
	C3	79	90	207	335	592
	C4	131	150	345	558	986

Asset Register Category	Criticality Index Band	In Year Monetised Risk Weighting (£ at 2020/21 prices) For Each Health Index Band				
		H1	H2	H3	H4	H5
33kV Pole	C1	16	19	43	69	122
	C2	23	27	61	99	174
	C3	35	40	91	148	261
	C4	58	66	152	247	436
66kV Pole	C1	24	27	63	102	180
	C2	34	39	90	145	256
	C3	51	59	134	218	385
	C4	85	98	224	363	641
33kV OHL (Tower Line) Conductor	C1	33	38	87	141	249
	C2	47	54	124	202	356
	C3	71	81	187	302	534
	C4	118	136	311	504	890
33kV Tower	C1	86	99	226	366	646
	C2	123	141	323	523	924
	C3	184	211	484	784	1385
	C4	307	352	807	1307	2309
33kV Fittings	C1	4	5	11	17	30
	C2	6	7	15	24	43
	C3	9	10	23	37	65
	C4	14	16	38	61	108
66kV OHL (Tower Line) Conductor	C1	44	51	117	190	335
	C2	64	73	167	271	479
	C3	95	109	251	406	718
	C4	159	182	418	677	1197
66kV Tower	C1	162	186	426	689	1218
	C2	231	265	608	985	1740
	C3	347	398	912	1477	2610
	C4	578	663	1520	2462	4350
66kV Fittings	C1	5	5	12	20	35
	C2	7	8	17	28	50
	C3	10	11	26	43	75
	C4	17	19	44	71	125
33kV UG Cable (Non Pressurised)	C1	471	541	1241	2009	3550
	C2	673	773	1772	2870	5072
	C3	1010	1160	2659	4306	7607
	C4	1683	1933	4431	7176	12679
33kV UG Cable (Oil)	C1	2515	2888	6621	10723	18945
	C2	3593	4125	9458	15318	27065
	C3	5389	6188	14188	22977	40597
	C4	8982	10313	23646	38295	67661
33kV UG Cable (Gas)	C1	366	420	963	1560	2757
	C2	523	600	1376	2229	3938
	C3	784	900	2064	3343	5907
	C4	1307	1501	3441	5572	9845
66kV UG Cable (Non Pressurised)	C1	943	1082	2482	4019	7101
	C2	1347	1546	3545	5741	10144
	C3	2020	2319	5318	8612	15216
	C4	3367	3865	8863	14353	25360
66kV UG Cable (Oil)	C1	2521	2894	6636	10748	18989
	C2	3601	4135	9480	15354	27128
	C3	5402	6202	14221	23030	40692
	C4	9003	10337	23701	38384	67819
66kV UG Cable (Gas)	C1	579	665	1526	2471	4365
	C2	828	951	2179	3529	6236
	C3	1242	1426	3269	5294	9354
	C4	2070	2376	5448	8824	15590

Asset Register Category	Criticality Index Band	In Year Monetised Risk Weighting (£ at 2020/21 prices) For Each Health Index Band				
		H1	H2	H3	H4	H5
EHV Sub Cable	C1	1179	1353	3103	5025	8878
	C2	1684	1933	4432	7178	12683
	C3	2525	2900	6649	10767	19024
	C4	4209	4833	11081	17946	31707
33kV CB (Air Insulated Busbars)(ID)(GM)	C1	318	365	837	1356	2396
	C2	454	522	1196	1937	3423
	C3	682	782	1794	2906	5134
	C4	1136	1304	2990	4843	8557
33kV CB (Air Insulated Busbars)(OD)(GM)	C1	269	309	708	1147	2026
	C2	384	441	1012	1638	2895
	C3	576	662	1518	2458	4342
	C4	961	1103	2529	4096	7237
33kV CB (Gas Insulated Busbars)(ID)(GM)	C1	351	403	925	1498	2646
	C2	502	576	1321	2140	3780
	C3	753	864	1982	3209	5670
	C4	1255	1440	3303	5349	9451
33kV CB (Gas Insulated Busbars)(OD)(GM)	C1	287	330	756	1225	2164
	C2	410	471	1080	1750	3092
	C3	616	707	1621	2625	4638
	C4	1026	1178	2701	4375	7730
33kV Switch (GM)	C1	235	270	619	1002	1771
	C2	336	386	884	1432	2530
	C3	504	579	1326	2148	3796
	C4	840	964	2211	3580	6326
33kV RMU	C1	302	347	796	1289	2277
	C2	432	496	1137	1841	3253
	C3	648	744	1705	2762	4879
	C4	1080	1239	2842	4603	8132
66kV CB (Air Insulated Busbars)(ID)(GM)	C1	877	1008	2310	3741	6610
	C2	1254	1439	3300	5344	9443
	C3	1880	2159	4950	8017	14164
	C4	3134	3598	8250	13361	23607
66kV CB (Air Insulated Busbars)(OD)(GM)	C1	908	1042	2389	3869	6836
	C2	1296	1489	3413	5527	9766
	C3	1945	2233	5120	8291	14649
	C4	3241	3721	8533	13819	24416
66kV CB (Gas Insulated Busbars)(ID)(GM)	C1	1115	1280	2935	4753	8399
	C2	1593	1829	4193	6791	11998
	C3	2389	2743	6290	10186	17997
	C4	3982	4572	10483	16977	29995
66kV CB (Gas Insulated Busbars)(OD)(GM)	C1	968	1111	2548	4127	7292
	C2	1383	1588	3641	5896	10417
	C3	2074	2382	5461	8844	15626
	C4	3457	3970	9102	14740	26044
33kV Transformer (GM)	C1	1424	1635	3748	6070	10725
	C2	2034	2335	5354	8671	15321
	C3	3051	3503	8031	13007	22981
	C4	5085	5838	13385	21678	38302
66kV Transformer (GM)	C1	1850	2124	4871	7889	13938
	C2	2643	3035	6958	11269	19911
	C3	3965	4552	10438	16904	29867
	C4	6608	7587	17396	28173	49778
132kV OHL (Tower Line) Conductor	C1	46	53	120	195	345
	C2	65	75	172	279	493
	C3	98	113	258	418	739
	C4	163	188	430	697	1231

Asset Register Category	Criticality Index Band	In Year Monetised Risk Weighting (£ at 2020/21 prices) For Each Health Index Band				
		H1	H2	H3	H4	H5
132kV Tower	C1	210	241	554	897	1584
	C2	300	345	791	1281	2263
	C3	451	517	1186	1921	3395
	C4	751	862	1977	3202	5658
132kV Fittings	C1	7	8	17	28	49
	C2	9	11	25	40	71
	C3	14	16	37	60	106
	C4	23	27	62	100	176
132kV UG Cable (Non Pressurised)	C1	1680	1929	4423	7163	12655
	C2	2400	2756	6318	10232	18079
	C3	3600	4133	9477	15348	27118
	C4	6000	6889	15795	25581	45197
132kV UG Cable (Oil)	C1	3169	3638	8341	13509	23868
	C2	4527	5197	11916	19298	34098
	C3	6790	7796	17874	28948	51147
	C4	11316	12993	29791	48246	85244
132kV UG Cable (Gas)	C1	953	1094	2508	4062	7176
	C2	1361	1563	3583	5802	10252
	C3	2041	2344	5374	8703	15378
	C4	3402	3907	8957	14506	25629
132kV Sub Cable	C1	2022	2322	5324	8622	15233
	C2	2889	3317	7605	12316	21761
	C3	4333	4975	11408	18475	32642
	C4	7222	8292	19013	30791	54403
132kV CB (Air Insulated Busbars)(ID)(GM)	C1	2518	2892	6630	10737	18971
	C2	3598	4131	9471	15338	27101
	C3	5397	6196	14207	23008	40651
	C4	8995	10327	23678	38346	67752
132kV CB (Air Insulated Busbars)(OD)(GM)	C1	1160	1332	3054	4947	8740
	C2	1658	1903	4363	7066	12485
	C3	2486	2855	6545	10600	18728
	C4	4144	4758	10908	17666	31214
132kV CB (Gas Insulated Busbars)(ID)(GM)	C1	3273	3758	8617	13956	24657
	C2	4676	5369	12310	19937	35225
	C3	7015	8054	18465	29905	52837
	C4	11691	13423	30776	49841	88062
132kV CB (Gas Insulated Busbars)(OD)(GM)	C1	2284	2623	6013	9738	17206
	C2	3263	3747	8590	13912	24580
	C3	4895	5620	12885	20868	36870
	C4	8158	9367	21475	34780	61450
132kV Transformer (GM)	C1	5115	5873	13465	21807	38530
	C2	7307	8390	19236	31153	55042
	C3	10960	12584	28853	46729	82563
	C4	18267	20974	48089	77882	137606

E.3 Weighting Factors for Determination of Long Term Risk

TABLE 239: TYPICAL FORECAST AGEING RATES FOR USE IN DETERMINATION OF CUMULATIVE DISCOUNTED POF WEIGHTINGS FOR RISK MATRICES

Asset Register Category	Forecast Ageing Rate	Comments
LV Poles	0.04359810	From Normal Expected Life for Wood Pole subdivision
LV Circuit Breaker	0.03996492	
LV Pillar (ID)	0.03996492	
LV Pillar (OD at Substation)	0.03996492	
LV Pillar (OD not at a Substation) LV Board (WM)	0.03996492 0.03996492	
LV UGB	0.04359810	
LV Board (X-type Network) (WM)	0.03996492	
6.6/11kV Poles	0.04359810	From Normal Expected Life for Wood Pole subdivision
20kV Poles	0.04359810	From Normal Expected Life for Wood Pole subdivision
HV Sub Cable	0.03996492	
6.6/11kV CB (GM) Primary	0.04359810	
6.6/11kV CB (GM) Secondary	0.04359810	
6.6/11kV Switch (GM)	0.04359810	
6.6/11kV RMU	0.04359810	
6.6/11kV X-type RMU	0.04359810	
20kV CB (GM) Primary	0.04359810	
20kV CB (GM) Secondary	0.04359810	
20kV Switch (GM)	0.04359810	
20kV RMU	0.04359810	
6.6/11kV Transformer (GM)	0.03996492	
20kV Transformer (GM)	0.03996492	
33kV Pole	0.04359810	From Normal Expected Life for Wood Pole subdivision
66kV Pole	0.04359810	From Normal Expected Life for Wood Pole subdivision
33kV OHL (Tower Line) Conductor	0.04359810	From Normal Expected Life for ACSR - greased subdivision
33kV Tower	0.02997369	From Normal Expected Life for Steelwork subcomponent
33kV Fittings	0.05994738	
66kV OHL (Tower Line) Conductor	0.04359810	From Normal Expected Life for ACSR - greased subdivision
66kV Tower	0.02997369	From Normal Expected Life for Steelwork subcomponent
66kV Fittings	0.05994738	
33kV UG Cable (Non Pressurised)	0.02397895	
33kV UG Cable (Oil)	0.03197194	From Normal Expected Life for Aluminium Sheath - Copper Conductor subdivision
33kV UG Cable (Gas)	0.03425565	From Normal Expected Life for Aluminium Sheath - Copper Conductor subdivision
66kV UG Cable (Non Pressurised)	0.02397895	
66kV UG Cable (Oil)	0.03197194	From Normal Expected Life for Aluminium Sheath - Copper Conductor subdivision
66kV UG Cable (Gas)	0.03425565	From Normal Expected Life for Aluminium Sheath - Copper Conductor subdivision
EHV Sub Cable	0.03996492	
33kV CB (Air Insulated Busbars)(ID)(GM)	0.03996492	
33kV CB (Air Insulated Busbars)(OD) (GM)	0.04795791	
33kV CB (Gas Insulated Busbars)(ID)(GM)	0.03996492	
33kV CB (Gas Insulated Busbars)(OD)(GM)	0.04795791	
33kV Switch (GM)	0.04359810	
33kV RMU	0.04359810	
66kV CB (Air Insulated Busbars)(ID)(GM)	0.04795791	
66kV CB (Air Insulated Busbars)(OD)(GM)	0.04359810	
66kV CB (Gas Insulated Busbars)(ID)(GM)	0.04359810	
66kV CB (Gas Insulated Busbars)(OD)(GM)	0.04795791	
33kV Transformer (GM)	0.03996492	From Normal Expected Life for Transformer - Pre 1980 subcomponent and subdivision

Asset Register Category	Forecast Ageing Rate	Comments
66kV Transformer (GM)	0.03996492	From Normal Expected Life for Transformer - Pre 1980 subcomponent and subdivision
132kV OHL (Tower Line) Conductor	0.04359810	From Normal Expected Life for ACSR - greased subdivision
132kV Tower	0.02997369	From Normal Expected Life for Steelwork subcomponent
132kV Fittings	0.05994738	
132kV UG Cable (Non Pressurised)	0.02397895	
132kV UG Cable (Oil)	0.03197194	From Normal Expected Life for Aluminium Sheath - Copper Conductor subdivision
132kV UG Cable (Gas)	0.03425565	From Normal Expected Life for Aluminium Sheath - Copper Conductor subdivision
132kV Sub Cable	0.03996492	
132kV CB (Air Insulated Busbars)(ID)(GM)	0.03996492	
132kV CB (Air Insulated Busbars)(OD)(GM)	0.04795791	
132kV CB (Gas Insulated Busbars)(ID)(GM)	0.03996492	
132kV CB (Gas Insulated Busbars)(OD)(GM)	0.04359810	
132kV Transformer (GM)	0.03996492	From Normal Expected Life for Transformer - Pre 1980 subcomponent and subdivision

TABLE 240: TYPICAL CUMULATIVE DISCOUNTED POF WEIGHTINGS FOR HEALTH INDICES BANDS FOR USE IN THE CALCULATION OF LONG TERM RISK FROM RISK MATRICES

Asset Register Category	Typical Cumulative Discounted POF Weightings for Each Health Index Band				
	HI1	HI2	HI3	HI4	HI5
LV Poles	0.1595	0.6526	1.3389	2.1126	3.0838
LV Circuit Breaker	0.0227	0.082	0.1708	0.2801	0.4269
LV Pillar (ID)	0.0254	0.0919	0.1916	0.3143	0.479
LV Pillar (OD at Substation)	0.0254	0.0919	0.1916	0.3143	0.479
LV Pillar (OD not at a Substation)	0.0254	0.0919	0.1916	0.3143	0.479
LV Board (WM)	0.0382	0.1379	0.2875	0.4715	0.7184
LV UGB	0.0431	0.1763	0.3617	0.5708	0.8332
LV Board (X-type Network) (WM)	0.0382	0.1379	0.2875	0.4715	0.7184
6.6/11kV Poles	0.1595	0.6526	1.3389	2.1126	3.0838
20kV Poles	0.1595	0.6526	1.3389	2.1126	3.0838
HV Sub Cable	0.1117	0.4038	0.8416	1.3802	2.1032
6.6/11kV CB (GM) Primary	0.0291	0.1191	0.2443	0.3855	0.5627
6.6/11kV CB (GM) Secondary	0.0375	0.1534	0.3148	0.4966	0.725
6.6/11kV Switch (GM)	0.0375	0.1534	0.3148	0.4966	0.725
6.6/11kV RMU	0.0375	0.1534	0.3148	0.4966	0.725
6.6/11kV X-type RMU	0.0375	0.1534	0.3148	0.4966	0.725
20kV CB (GM) Primary	0.0291	0.1191	0.2443	0.3855	0.5627
20kV CB (GM) Secondary	0.0375	0.1534	0.3148	0.4966	0.725
20kV Switch (GM)	0.0375	0.1534	0.3148	0.4966	0.725
20kV RMU	0.0375	0.1534	0.3148	0.4966	0.725
6.6/11kV Transformer (GM)	0.0431	0.1559	0.325	0.533	0.8121
20kV Transformer (GM)	0.0431	0.1559	0.325	0.533	0.8121
33kV Pole	0.1595	0.6526	1.3389	2.1126	3.0838
66kV Pole	0.1595	0.6526	1.3389	2.1126	3.0838
33kV OHL (Tower Line) Conductor	0.0448	0.1832	0.3758	0.593	0.8656
33kV Tower	0.3012	0.7709	1.6673	2.7647	4.8615

Asset Register Category	Typical Cumulative Discounted POF Weightings for Each Health Index Band				
	HI1	HI2	HI3	HI4	HI5
33kV Fittings	0.0694	0.4162	0.6737	0.8979	1.1667
66kV OHL (Tower Line) Conductor	0.0448	0.1832	0.3758	0.593	0.8656
66kV Tower	0.3012	0.7709	1.6673	2.7647	4.8615
66kV Fittings	0.0694	0.4162	0.6737	0.8979	1.1667
33kV UG Cable (Non Pressurised)	0.3637	0.7714	1.6978	2.8015	5.0373
33kV UG Cable (Oil)	11.5754	31.6439	67.9831	112.9162	194.2315
33kV UG Cable (Gas)	24.8906	73.5116	156.6694	260.7076	433.9966
66kV UG Cable (Non Pressurised)	0.3637	0.7714	1.6978	2.8015	5.0373
66kV UG Cable (Oil)	11.5754	31.6439	67.9831	112.9162	194.2315
66kV UG Cable (Gas)	24.8906	73.5116	156.6694	260.7076	433.9966
EHV Sub Cable	0.1117	0.4038	0.8416	1.3802	2.1032
33kV CB (Air Insulated Busbars)(ID)(GM)	0.1234	0.4457	0.9291	1.5237	2.3219
33kV CB (Air Insulated Busbars)(OD)(GM)	0.1291	0.6052	1.2054	1.7886	2.5091
33kV CB (Gas Insulated Busbars)(ID)(GM)	0.1234	0.4457	0.9291	1.5237	2.3219
33kV CB (Gas Insulated Busbars)(OD)(GM)	0.1291	0.6052	1.2054	1.7886	2.5091
33kV Switch (GM)	0.1248	0.5106	1.0476	1.653	2.4129
33kV RMU	0.1248	0.5106	1.0476	1.653	2.4129
66kV CB (Air Insulated Busbars)(ID)(GM)	0.2963	1.3896	2.7676	4.1066	5.7609
66kV CB (Air Insulated Busbars)(OD)(GM)	0.2865	1.1723	2.4053	3.7953	5.54
66kV CB (Gas Insulated Busbars)(ID)(GM)	0.2865	1.1723	2.4053	3.7953	5.54
66kV CB (Gas Insulated Busbars)(OD)(GM)	0.2963	1.3896	2.7676	4.1066	5.7609
33kV Transformer (GM)	0.2511	0.9075	1.8915	3.1021	4.7271
66kV Transformer (GM)	0.2511	0.9075	1.8915	3.1021	4.7271
132kV OHL (Tower Line) Conductor	0.0448	0.1832	0.3758	0.593	0.8656
132kV Tower	0.3012	0.7709	1.6673	2.7647	4.8615
132kV Fittings	0.0694	0.4162	0.6737	0.8979	1.1667
132kV UG Cable (Non Pressurised)	0.3637	0.7714	1.6978	2.8015	5.0373
132kV UG Cable (Oil)	11.5754	31.6439	67.9831	112.9162	194.2315
132kV UG Cable (Gas)	24.8906	73.5116	156.6694	260.7076	433.9966
132kV Sub Cable	0.1117	0.4038	0.8416	1.3802	2.1032
132kV CB (Air Insulated Busbars)(ID)(GM)	0.2384	0.8615	1.7957	2.945	4.4876
132kV CB (Air Insulated Busbars)(OD)(GM)	0.2495	1.1697	2.3297	3.4569	4.8495
132kV CB (Gas Insulated Busbars)(ID)(GM)	0.2384	0.8615	1.7957	2.945	4.4876
132kV CB (Gas Insulated Busbars)(OD)(GM)	0.2412	0.9869	2.0248	3.1948	4.6636
132kV Transformer (GM)	0.2511	0.9075	1.8915	3.1021	4.7271

TABLE 241: RISK MATRIX WEIGHTINGS - RISK INDEX (LONG TERM RISK)

Asset Register Category	Criticality Index Band	Risk Index or Monetised Long Term Risk Weighting (£ at 20/21 prices) For Each Health Index Band				
		HI1	HI2	HI3	HI4	HI5
LV Poles	C1	287	1174	2408	3800	5547
	C2	410	1677	3441	5429	7924
	C3	615	2515	5161	8143	11887
	C4	1025	4192	8601	13572	19811
LV Circuit Breaker	C1	386	1394	2904	4762	7257
	C2	551	1991	4148	6802	10367
	C3	827	2987	6222	10203	15551
	C4	1378	4978	10370	17006	25918
LV Pillar (ID)	C1	410	1482	3090	5069	7726
	C2	585	2118	4415	7242	11037
	C3	878	3176	6622	10863	16556
	C4	1463	5294	11037	18105	27593
LV Pillar (OD at Substation)	C1	419	1515	3158	5180	7894
	C2	598	2164	4511	7400	11277
	C3	897	3245	6766	11100	16916
	C4	1495	5409	11277	18499	28193
LV Pillar (OD not at a Substation)	C1	379	1371	2859	4690	7147
	C2	541	1959	4084	6700	10210
	C3	812	2938	6126	10049	15315
	C4	1354	4897	10210	16749	25526
LV Board (WM)	C1	674	2433	5073	8319	12676
	C2	963	3476	7247	11885	18108
	C3	1444	5214	10870	17827	27162
	C4	2407	8690	18117	29712	45271
LV UGB	C1	479	1960	4022	6346	9264
	C2	685	2800	5745	9066	13234
	C3	1027	4200	8618	13599	19851
	C4	1711	7001	14363	22666	33085
LV Board (X-type Network) (WM)	C1	712	2569	5357	8785	13385
	C2	1017	3671	7652	12550	19122
	C3	1525	5506	11479	18825	28683
	C4	2542	9176	19131	31375	47804
6.6/11kV Poles	C1	461	1888	3874	6112	8922
	C2	659	2697	5534	8732	12746
	C3	989	4046	8301	13098	19119
	C4	1648	6743	13835	21830	31865
20kV Poles	C1	504	2063	4232	6678	9747
	C2	720	2947	6046	9539	13925
	C3	1080	4420	9069	14309	20887
	C4	1801	7367	15114	23848	34812
HV Sub Cable	C1	29395	106264	221475	363212	553476
	C2	41993	151805	316393	518875	790681
	C3	62989	227708	474589	778312	1186021
	C4	104982	379513	790981	1297187	1976702
6.6/11kV CB (GM) Primary	C1	1490	6100	12512	19743	28819
	C2	2129	8714	17874	28205	41170
	C3	3194	13071	26811	42307	61755
	C4	5323	21785	44685	70512	102924
6.6/11kV CB (GM) Secondary	C1	652	2668	5475	8638	12610
	C2	932	3812	7822	12339	18015
	C3	1398	5717	11733	18509	27022
	C4	2329	9529	19555	30849	45037
6.6/11kV Switch (GM)	C1	608	2486	5103	8049	11752
	C2	868	3552	7289	11499	16788
	C3	1303	5328	10934	17249	25182
	C4	2171	8880	18224	28748	41970

Asset Register Category	Criticality Index Band	Risk Index or Monetised Long Term Risk Weighting (£ at 20/21 prices) For Each Health Index Band				
		HI1	HI2	HI3	HI4	HI5
6.6/11kV RMU	C1	728	2977	6110	9639	14072
	C2	1040	4253	8729	13770	20103
	C3	1560	6380	13093	20655	30154
	C4	2599	10634	21822	34424	50257
6.6/11kV X-type RMU	C1	819	3351	6876	10847	15836
	C2	1170	4787	9823	15496	22622
	C3	1755	7180	14734	23243	33934
	C4	2925	11966	24557	38739	56556
20kV CB (GM) Primary	C1	1529	6260	12840	20261	29574
	C2	2185	8942	18343	28944	42249
	C3	3277	13413	27514	43416	63373
	C4	5462	22356	45857	72361	105622
20kV CB (GM) Secondary	C1	659	2696	5532	8726	12740
	C2	941	3851	7902	12466	18199
	C3	1412	5776	11854	18699	27299
	C4	2353	9627	19756	31165	45499
20kV Switch (GM)	C1	630	2576	5287	8341	12177
	C2	900	3681	7553	11915	17395
	C3	1350	5521	11330	17873	26093
	C4	2249	9201	18883	29788	43488
20kV RMU	C1	733	2997	6151	9703	14166
	C2	1047	4282	8787	13861	20237
	C3	1570	6423	13180	20792	30355
	C4	2617	10704	21967	34653	50591
6.6/11kV Transformer (GM)	C1	672	2430	5067	8309	12661
	C2	960	3472	7238	11871	18087
	C3	1440	5208	10857	17806	27130
	C4	2400	8680	18095	29677	45216
20kV Transformer (GM)	C1	711	2571	5360	8790	13393
	C2	1015	3673	7657	12557	19133
	C3	1523	5509	11485	18836	28699
	C4	2539	9182	19142	31394	47832
33kV Pole	C1	318	1301	2669	4211	6146
	C2	454	1858	3812	6015	8781
	C3	681	2787	5718	9023	13171
	C4	1135	4645	9531	15038	21952
66kV Pole	C1	468	1915	3928	6198	9047
	C2	668	2735	5611	8854	12924
	C3	1003	4103	8417	13281	19387
	C4	1671	6838	14029	22135	32311
33kV OHL (Tower Line) Conductor	C1	650	2659	5453	8605	12561
	C2	929	3798	7791	12293	17945
	C3	1393	5697	11686	18440	26917
	C4	2322	9495	19477	30733	44861
33kV Tower	C1	1664	4259	9212	15275	26860
	C2	2377	6085	13160	21822	38372
	C3	3566	9127	19740	32732	57557
	C4	5943	15212	32900	54554	95929
33kV Fittings	C1	102	611	990	1319	1714
	C2	146	873	1414	1884	2448
	C3	218	1310	2121	2826	3672
	C4	364	2183	3534	4710	6121
66kV OHL (Tower Line) Conductor	C1	874	3574	7332	11569	16888
	C2	1249	5106	10474	16528	24125
	C3	1873	7659	15711	24792	36188
	C4	3122	12765	26185	41319	60314

Asset Register Category	Criticality Index Band	Risk Index or Monetised Long Term Risk Weighting (£ at 20/21 prices) For Each Health Index Band				
		HI1	HI2	HI3	HI4	HI5
66kV Tower	C1	3136	8026	17358	28783	50612
	C2	4480	11465	24797	41118	72303
	C3	6719	17198	37195	61677	108454
	C4	11199	28663	61992	102795	180757
66kV Fittings	C1	118	708	1146	1527	1984
	C2	169	1011	1637	2181	2834
	C3	253	1517	2455	3272	4252
	C4	422	2528	4092	5454	7086
33kV UG Cable (Non Pressurised)	C1	9140	19386	42667	70404	126592
	C2	13057	27694	60953	100578	180846
	C3	19586	41542	91430	150867	271269
	C4	32643	69236	152384	251444	452115
33kV UG Cable (Oil)	C1	48772	133329	286441	475762	818377
	C2	69674	190469	409200	679660	1169109
	C3	104511	285704	613801	1019490	1753664
	C4	174185	476174	1023002	1699151	2922774
33kV UG Cable (Gas)	C1	7097	20960	44670	74333	123741
	C2	10138	29942	63813	106189	176771
	C3	15207	44913	95720	159285	265159
	C4	25346	74855	159533	265473	441930
66kV UG Cable (Non Pressurised)	C1	18282	38775	85341	140819	253203
	C2	26117	55393	121916	201170	361719
	C3	39175	83089	182874	301755	542578
	C4	65291	138482	304789	502926	904297
66kV UG Cable (Oil)	C1	48886	133640	287109	476872	820286
	C2	69837	190914	410156	681247	1171839
	C3	104755	286371	615234	1021870	1757758
	C4	174592	477286	1025390	1703117	2929598
66kV UG Cable (Gas)	C1	11238	33189	70733	117704	195941
	C2	16054	47413	101047	168149	279915
	C3	24080	71119	151570	252222	419870
	C4	40134	118532	252617	420370	699785
EHV Sub Cable	C1	22867	82665	172290	282551	430562
	C2	32667	118093	246129	403644	615088
	C3	49001	177139	369193	605466	922632
	C4	81668	295232	615322	1009110	1537720
33kV CB (Air Insulated Busbars)(ID)(GM)	C1	6175	22304	46495	76251	116196
	C2	8822	31863	66422	108930	165994
	C3	13233	47795	99633	163395	248990
	C4	22055	79658	166054	272325	414984
33kV CB (Air Insulated Busbars)(OD)(GM)	C1	5464	25616	51021	75706	106202
	C2	7806	36594	72887	108151	151717
	C3	11709	54892	109330	162226	227576
	C4	19516	91486	182217	270377	379293
33kV CB (Gas Insulated Busbars)(ID)(GM)	C1	6821	24635	51354	84219	128337
	C2	9744	35193	73362	120313	183339
	C3	14616	52789	110044	180469	275009
	C4	24359	87982	183406	300781	458347
33kV CB (Gas Insulated Busbars)(OD)(GM)	C1	5836	27359	54492	80856	113428
	C2	8337	39084	77846	115509	162039
	C3	12506	58626	116768	173264	243059
	C4	20843	97711	194614	288773	405098
33kV Switch (GM)	C1	4617	18891	38759	61157	89272
	C2	6596	26987	55370	87368	127532
	C3	9894	40481	83055	131052	191297
	C4	16490	67468	138425	218420	318829

Asset Register Category	Criticality Index Band	Risk Index or Monetised Long Term Risk Weighting (£ at 20/21 prices) For Each Health Index Band				
		HI1	HI2	HI3	HI4	HI5
33kV RMU	C1	5936	24285	49825	78618	114760
	C2	8479	34692	71178	112312	163943
	C3	12719	52039	106768	168468	245914
	C4	21199	86731	177946	280780	409857
66kV CB (Air Insulated Busbars)(ID)(GM)	C1	17818	83564	166430	246950	346432
	C2	25454	119377	237757	352786	494903
	C3	38181	179065	356635	529180	742354
	C4	63636	298441	594392	881966	1237256
66kV CB (Air Insulated Busbars)(OD)(GM)	C1	17819	72911	149596	236047	344558
	C2	25455	104158	213709	337210	492225
	C3	38183	156237	320564	505815	738338
	C4	63638	260395	534273	843024	1230563
66kV CB (Gas Insulated Busbars)(ID)(GM)	C1	21891	89572	183782	289988	423296
	C2	31272	127960	262546	414269	604708
	C3	46909	191940	393819	621403	907062
	C4	78181	319900	656365	1035672	1511770
66kV CB (Gas Insulated Busbars)(OD)(GM)	C1	19657	92188	183606	272436	382184
	C2	28081	131697	262294	389195	545978
	C3	42122	197545	393441	583792	818967
	C4	70203	329241	655734	972987	1364944
33kV Transformer (GM)	C1	27629	99853	208124	341328	520129
	C2	39470	142648	297320	487612	743041
	C3	59205	213972	445980	731417	1114562
	C4	98674	356619	743301	1219029	1857603
66kV Transformer (GM)	C1	35907	129772	270484	443599	675974
	C2	51296	185389	386405	633713	965677
	C3	76944	278083	579608	950570	1448515
	C4	128240	463472	966014	1584283	2414192
132kV OHL (Tower Line) Conductor	C1	899	3678	7544	11905	17378
	C2	1285	5254	10778	17007	24825
	C3	1927	7881	16167	25510	37238
	C4	3212	13135	26944	42517	62063
132kV Tower	C1	4078	10438	22576	37435	65826
	C2	5826	14912	32251	53478	94038
	C3	8739	22368	48377	80218	141056
	C4	14566	37279	80628	133696	235094
132kV Fittings	C1	166	997	1614	2152	2796
	C2	238	1425	2306	3074	3994
	C3	356	2137	3459	4611	5991
	C4	594	3562	5766	7684	9985
132kV UG Cable (Non Pressurised)	C1	32582	69107	152099	250975	451272
	C2	46546	98724	217284	358536	644674
	C3	69820	148086	325927	537804	967011
	C4	116366	246809	543211	896340	1611684
132kV UG Cable (Oil)	C1	61446	167976	360876	599395	1031043
	C2	87780	239966	515538	856280	1472920
	C3	131670	359949	773306	1284420	2209379
	C4	219450	599914	1288843	2140698	3682297
132kV UG Cable (Gas)	C1	18474	54562	116283	193502	322121
	C2	26392	77945	166118	276431	460171
	C3	39588	116918	249178	414648	690259
	C4	65980	194863	415296	691078	1150430
132kV Sub Cable	C1	39235	141837	295616	484801	738758
	C2	56050	202624	422308	692573	1055369
	C3	84075	303935	633462	1038860	1583053
	C4	140125	506559	1055770	1731433	2638422

Asset Register Category	Criticality Index Band	Risk Index or Monetised Long Term Risk Weighting (£ at 20/21 prices) For Each Health Index Band				
		HI1	HI2	HI3	HI4	HI5
132kV CB (Air Insulated Busbars)(ID)(GM)	C1	48877	176625	368154	603784	920048
	C2	69824	252321	525935	862548	1314354
	C3	104736	378482	788902	1293823	1971531
	C4	174560	630803	1314837	2156371	3285885
132kV CB (Air Insulated Busbars)(OD) (GM)	C1	23566	110482	220049	326517	458053
	C2	33666	157832	314355	466452	654361
	C3	50499	236748	471533	699679	981542
	C4	84165	394580	785888	1166131	1635903
132kV CB (Gas Insulated Busbars)(ID)(GM)	C1	63529	229573	478518	784784	1195856
	C2	90755	327961	683597	1121120	1708366
	C3	136133	491941	1025396	1681679	2562548
	C4	226889	819902	1708994	2802799	4270914
132kV CB (Gas Insulated Busbars)(OD) (GM)	C1	44852	183516	376515	594078	867204
	C2	64074	262165	537878	848683	1238863
	C3	96110	393248	806817	1273025	1858294
	C4	160184	655413	1344696	2121708	3097157
132kV Transformer (GM)	C1	99261	358739	747719	1226276	1868646
	C2	141802	512485	1068171	1751822	2669495
	C3	212702	768727	1602256	2627734	4004242
	C4	354504	1281212	2670427	4379556	6673737

APPENDIX F
WORKED EXAMPLES

F.1 Probability of Failure (PoF)

The described methodology is capable of representing a very wide range of asset conditions and situations. In order to provide the reader with some clarity, this section works through a selection of typical scenarios with references to the relevant section of the methodology. The examples begin with the simplest scenario first. In order to avoid repetition, each subsequent example will focus on the key differences with the previous examples. The scenarios presented here are not exhaustive but provide an illustration of how the methodology works.

Example 1: A new LV pole with no associated condition information

The asset used in this example is a one-year-old steel LV pole, 5km from the coast, at an altitude of 100m, in corrosion zone 3. No condition information is available for this asset. For this asset, the following calculation steps enable the PoF (and associated Heath Index Band) to be determined:

Normal Expected Life (see Section 6.1.3)

1. The Normal Expected Life of a steel pole is given by Table 20 “Normal Expected Life” as **50** years

Expected Life (see Section 6.1.4)

2. The Distance from Coast Factor is given by Table 22 “Distance from Coast Factor Lookup Table” as **1.2**
3. The Altitude Factor is given by Table 23 “Altitude Factor Lookup Table” as **1**
4. The Corrosion Category Factor is given by Table 24 “Corrosion Category Factor Lookup Table” as **1**
5. The Location Factor is determined in accordance with EQ. 13 as

$$\text{Location Factor} = \text{MAX}(\text{Distance From Coast Factor, Altitude Factor, Corrosion Factor}) + \left(\left((\text{COUNT of factors greater than 1}) - 1\right) \times \text{INC}\right)$$

giving **MAX (1.2, 1, 1) + 0 = 1.2**

6. The Duty Factor is given by Table 8 “Duty Factor Methodology” as **1**
7. The Expected Life is given by EQ. 4 as

$$\text{Expected Life} = \frac{\text{Normal Expected Life}}{(\text{Duty Factor} \times \text{Location Factor})}$$

giving **50 / (1.2 x 1) = 41.66667** years

β1 Initial Ageing Rate (see Section 6.1.5)

8. The Initial Ageing Rate is given by EQ. 5 as

$$\beta_1 = \frac{\ln\left(\frac{H_{\text{expected life}}}{H_{\text{new}}}\right)}{\text{Expected Life}}$$

giving **ln(5.5 / 0.5) / 41.66667 = 0.05755**

Initial Health Score (see Section 6.1.6)

9. The Initial Health Score is given by EQ. 6 as

$$\text{Initial Health Score} = H_{new} \times e^{(\beta_1 \times age)}$$

giving **0.5 x e^(0.05755 x 1) = 0.52962**

Current Health Score (see Section 6.1.7)

10. The Observed Condition Modifiers are given by Table 108 to Table 111. As no condition information is available, the default values apply, namely Condition Input Factor = **1**, Condition Input Cap = **10**, Condition Input Collar = **0.5**
11. The Measured Condition Modifier is given by Table 192 “Measured Condition Input - LV Pole: Pole Decay / Deterioration”. As no condition information is available, the default values apply, namely Condition Input Factor = **1**, Condition Input Cap = **10**, Condition Input Collar = **0.5**
12. The Health Score Modifier is calculated using the MMI technique described in Section 6.7.2. In this case, all input factors are the same, resulting in a Health Score Modifier that consists of Health Score Factor = **1**, Health Score Cap = **10**, Health Score Collar = **0.5**
13. The Current Health Score is given by EQ. 7 as

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

giving **0.52962 x 1 x 1 = 0.52962**. The test conditions in EQ. 8 and EQ. 9 confirm that this value is within the cap and collar range (0.5 to 10), so the Current Health Score is confirmed as **0.52962**
14. The corresponding Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI1**

β_2 Forecast Ageing Rate (see Section 6.1.8)

15. The Forecast Ageing Rate is given by EQ. 10 as

$$\beta_2 = \frac{\ln\left(\frac{\text{Current Health Score}}{H_{new}}\right)}{\text{Age}}$$

giving **ln(0.52962/ 0.5) / 1 = 0.05755**
16. The test condition in EQ. 11 confirms that this result for β_2 is within the cap of 2 x β_1

Ageing Reduction Factor (see Section 6.1.9)

17. The Current Health Score is less than 2, so Table 216 “Ageing Reduction Factor” confirms that the Ageing Reduction Factor is **1**

Future Health Score – Deterioration (see Section 6.1.10)

18. The Future Health Score is given by EQ. 12

$$\text{Future Health Score} = \text{Current Health Score} \times e^{((\beta_2/r)\times t)}$$

    For a five-year forecast period, t is equal to **5**, so the Future Health Score is therefore **0.52962 x e^((0.05755 / 1) x 5)) = 0.70620**

19. The future Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI1**
20. The value of K is given by Table 21 “PoF Curve Parameters” as **0.00029**
21. The Current Health Score is <=4, so the PoF if given by setting H=4 in EQ. 3

$$\text{PoF} = K \times \left[1 + (C \times H) + \frac{(C \times H)^2}{2!} + \frac{(C \times H)^3}{3!}\right]$$

    This gives a PoF value of **0.00029 x (1 + (1.087 x 4) + (1.087 x 4)^2 / 2 + (1.087 x 4)^3 / 6) = 0.00827**

22. The Future Health Score is <=4, so the future PoF is again given by EQ. 3 as **0.00029 x (1 + (1.087 x 4) + (1.087 x 4)^2 / 2 + (1.087 x 4)^3 / 6) = 0.00827**

In summary, this asset would be banded into the most reliable Health Index Band (HI1) and would remain there for the 5-year period under review.

Example 2: An ageing LV pole

The asset used in this example is a 50-year-old steel LV pole in the same location as the previous example i.e. located outdoors, 5km from the coast, at an altitude of 100m, in corrosion zone 3. No condition information is available for this asset.

Steps 1 to 8 are exactly the same as in the previous example.

<u>Initial Health Score (see Section 6.1.6)</u>

9. The Initial Health Score is given by EQ. 6 as

$$\text{Initial Health Score} = H_{new} \times e^{(\beta_1 \times \text{age})}$$

giving **0.5 x e^(0.05755 x 50) = 8.88490.** However, the result is capped to the maximum permissible value of **5.5**

<u>Current Health Score (see Section 6.1.7)</u>

Steps 10 to 12 are exactly the same as in the previous example.

13. The Current Health Score is given by EQ. 7 as

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

giving **5.5 x 1 x 1 = 5.5**. The test conditions in EQ. 8 and EQ. 9 confirm that this value is within the cap and collar range (0.5 to 10), so the Current Health Score is confirmed as **5.5**

14. The corresponding Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI3**

<u>β_2 Forecast Ageing Rate (see Section 6.1.8)</u>

15. The Forecast Ageing Rate is given by EQ. 10 as

$$\beta_2 = \frac{\ln\left(\frac{\text{Current Health Score}}{H_{new}}\right)}{\text{Age}}$$

giving **ln(5.5 / 0.5) / 50 = 0.04796**

16. The test condition in EQ. 11confirms that this result for β_2 is within the cap of 2 x β_1

<u>Ageing Reduction Factor (see Section 6.1.9)</u>

17. The Current Health Score is 5.5, so Table 216 “Ageing Reduction Factor” increases the Ageing Reduction Factor to **1.5**

Future Health Score – Deterioration (see Section 6.1.10)

18. The Future Health Score is given by EQ. 12

$$\text{Future Health Score} = \text{Current Health Score} \times e^{((\beta_2/r) \times t)}$$

For a five-year forecast period, t is equal to **5**, so the Future Health Score is therefore **5.5 x e^((0.04796 / 1.5) x 5)) = 6.45340**

19. The future Health Index Band is given by Table 5 "Health Index Banding Criteria" as **HI3**
20. The value of K is given by Table 21 "PoF Curve Parameters" as **0.00029**
21. The Current Health Score is >4, so the current PoF from EQ. 3 where H = Health Score

$$\text{PoF} = K \times \left[1 + (C \times H) + \frac{(C \times H)^2}{2!} + \frac{(C \times H)^3}{3!}\right]$$

is **0.00029 x (1 + (1.087 x 5.5) + (1.087 x 5.5)^2 / 2 + (1.087 x 5.5)^3 / 6) = 0.01753** – approximately twice that of the new pole in the first example

22. Future Health Score is >4, so the future PoF is similarly given by EQ. 3 as **0.00029 x (1 + (1.087 x 6.45340) + (1.087 x 6.45340)^2 / 2 + (1.087 x 6.45340)^3 / 6) = 0.02614** – approximately three times that of the new pole in the first example

In summary, this asset would be banded into the middle Health Index Band (HI3) and would still be in the same band (HI3) by the end of the 5-year period under review, when it would be approximately three times more likely to fail than a new pole.

Example 3: A mid-life LV pole with evidence of degraded condition

The asset used in this example is a 25-year-old steel LV pole in the same location as the previous example i.e. located outdoors, 5km from the coast, at an altitude of 100m, in corrosion zone 3. The pole has been inspected and was found to have significant loss of residual strength, although within an acceptable level.

Steps 1 to 8 are exactly the same as in the previous example.

Initial Health Score (see Section 6.1.6)

9. The Initial Health Score is given by EQ. 6 as

$$\text{Initial Health Score} = H_{new} \times e^{(\beta_1 \times \text{age})}$$

giving **0.5 x e^(0.05755 x 25) = 2.10768**

Current Health Score (see Section 6.1.7)

Step 10 is the same as in the previous example.

11. The Measured Condition Modifier is given by Table 192 “Measured Condition Input - LV Pole: Pole Decay / Deterioration”. The pole has significant loss of residual strength, although within an acceptable level and so would be classified as having “High” deterioration. Therefore, Condition Input Factor =**1.4**, Condition Input Cap = **10**, Condition Input Collar = **5.5**
12. The Health Score Modifier is calculated using the MMI technique described in Section 6.7.2. In this case, the result is driven by the highest Condition Input Factor, resulting in a Health Score Modifier that consists of Health Score Factor = **1.4**, Health Score Cap = **10**, Health Score Collar = **5.5**
13. The Current Health Score is given by EQ. 7 as

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

giving **2.10768 x 1.4 x 1 = 2.95076**. However, the test conditions in EQ. 8 and EQ. 9 show that this is outside the cap and collar range (5.5 to 10), so the Current Health Score is collared to **5.5**

14. The corresponding Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI3**

β_2 Forecast Ageing Rate (see Section 6.1.8)

15. The Forecast Ageing Rate is given by EQ. 10 as

$$\beta_2 = \frac{\ln\left(\frac{\text{Current Health Score}}{H_{new}}\right)}{\text{Age}}$$

giving **ln(5.5 / 0.5) / 25 = 0.09592**.

16. The test condition in EQ. 11confirms that this result for β_2 is within the cap of 2 x β_1

Ageing Reduction Factor (see Section 6.1.9)

17. The Current Health Score is 5.5, so Table 216 “Ageing Reduction Factor” increases the Ageing Reduction Factor to **1.5**

Future Health Score – Deterioration (see Section 6.1.10)

18. The Future Health Score is given by EQ. 12

$$\textbf{Future Health Score} = \textbf{Current Health Score} \times e^{((\beta_2/r)\times t)}$$

For a five-year forecast period, t is equal to **5**, so the Future Health Score is therefore **5.5 x e^((0.09592 / 1.5) x 5)) = 7.57208**

19. The future Health Index Band is given by Table 5 “Health Index Banding Criteria” as **HI4**
20. The value of K is given by Table 21“PoF Curve Parameters” as **0.00029**
21. The Current Health Score is >4, so the current PoF from EQ. 3 where H = Health Score

$$\text{PoF} = K \times \left[1 + (C \times H) + \frac{(C \times H)^2}{2!} + \frac{(C \times H)^3}{3!}\right]$$

is **0.00029 x (1 + (1.087 x 5.5) + (1.087 x 5.5)^2 / 2 + (1.087 x 5.5)^3 / 6) = 0.01753** - approximately twice that of the new pole in the first example

22. Future Health Score is >4, so the future PoF is similarly given by EQ. 3 as **0.00029 x (1 + (1.087 x 7.57208) + (1.087 x 7.57208)^2 / 2 + (1.087 x 7.57208)^3 / 6) = 0.03945** – approximately five times that of the new pole in the first example

In summary, this asset would be banded into the middle Health Index Band (HI3) and would progress to HI4 by the end of the 5-year period under review, when it would be approximately five times more likely to fail than a new pole.

Example 4: An EHV transformer in good condition

The asset used in this example is a 40 year old 33kV transformer, located outdoors, 5km from the coast, at an altitude of 100m, in corrosion zone 3. It is 50% loaded and averages 5 taps per day. Condition information is available, showing that the main transformer tank has low levels of DGA. This example illustrates how the health scores of two asset sub-components are combined to give an overall health score.

<u>Normal Expected Life (see Section 6.1.3)</u>

1. The Normal Expected Life of a pre-1980 33kV transformer and tapchanger is given by Table 20 “Normal Expected Life” as **60** years

<u>Expected Life (see Section 6.1.4)</u>

2. The Distance from Coast Factor is given by Table 22 “Distance from Coast Factor Lookup Table” as **1.1**
3. The Altitude Factor is given by Table 23 “Altitude Factor Lookup Table” as **0.9**
4. The Corrosion Category Factor is given by Table 24 “Corrosion Category Factor Lookup Table” as **1**
5. The Location Factor is determined in accordance with EQ. 13 as

$$\text{Location Factor} = \text{MAX}(\text{Distance From Coast Factor, Altitude Factor, Corrosion Factor}) + \left(\left((\text{COUNT of factors greater than } 1) - 1\right) \times \text{INC}\right)$$

   giving **MAX (1.1, 0.9, 1) + 0 = 1.1**

6. The Transformer Duty Factor is given by Table 34 “Duty Factor Lookup Tables - Grid & Primary Transformers” as **1**
7. The Tapchanger Duty Factor is given by Table 34 “Duty Factor Lookup Tables - Grid & Primary Transformers” as **0.9**
8. The Transformer Expected Life is given by EQ. 4 as

$$\text{Expected Life} = \frac{\text{Normal Expected Life}}{(\text{Duty Factor} \times \text{Location Factor})}$$

   giving **60 / (1.1 x 1) = 54.54545** years

9. The Tapchanger Expected Life is given similarly by EQ. 4 as **60 / (1.1 x 0.9) = 60.60606** years

<u>β1 Initial Ageing Rate (see Section 6.1.5)</u>

10. The Transformer Initial Ageing Rate is given by EQ. 5 as

$$\beta_1 = \frac{\ln\left(\frac{H_{\text{expected life}}}{H_{\text{new}}}\right)}{\text{Expected Life}}$$

   giving **ln(5.5 / 0.5) / 54.55 = 0.04396**

11. The Tapchanger Initial Ageing Rate is given similarly by EQ. 5 as **ln(5.5 / 0.5) / 60.61 = 0.03957**

Initial Health Score (see Section 6.1.6)

12. The Transformer Initial Health Score is given by EQ. 6 as

$$\text{Initial Health Score} = H_{new} \times e^{(\beta_1 \times \text{age})}$$

giving **0.5 x e^(0.04396 x 40) = 2.90174**

13. The Tapchanger Initial Health Score is given similarly by EQ. 6 as **0.5 x e^(0.03957 x 40) = 2.43382**

Current Health Score (see Section 6.1.7)

14. The Health Score Modifier is calculated using the MMI technique described in Section 6.8. In this case, all input factors are neutral, resulting in a Health Score Modifier that consists of Health Score Factor = **1**, Health Score Cap = **10**, Health Score Collar = **0.5** for both the Transformer and the Tapchanger
15. The Transformer Current Health Score is given by EQ. 7 as

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

giving **2.90174 x 1 = 2.90174**. The test conditions in EQ. 8 and EQ. 9 confirm that this value is within the cap and collar range (0.5 to 10), so the Transformer Current Health Score is confirmed as **2.90174**

16. The Tapchanger Current Health Score is similarly given by EQ. 7 as **2.43382 x 1 = 2.43382** EQ. 8 and EQ. 9 confirm that this value is within the cap and collar range (0.5 to 10), so the Tapchanger Current Health Score is confirmed as **2.43382**
17. The combined Current Health Score is derived according to Section 6.2 as **MAX(2.90174, 2.43382) = 2.90174**
18. The corresponding Health Index Band is given by Table 5 as **HI1**

The derivation of the PoF and Future Health Score then follows the same pattern as described in Steps 15 to 22 in the first example. In this case, the transformer will remain in Health Index Band HI1 through to the end of the 5-year period under review.

Example 5: An EHV transformer with rising DGA levels

The asset used in this example is the same 40 year old 33kV transformer from example 4, which is located outdoors, 5km from the coast, at an altitude of 100m, in corrosion zone 3. It is 50% loaded and averages 5 taps per day. Additional condition information is available, showing that the DGA in the main transformer has risen from 10ppm (Hydrogen, Methane, Ethylene, Ethane) and 5ppm (Acetylene) to 50ppm (Hydrogen), 25ppm (Methane, Ethylene, Ethane) and 10ppm (Acetylene). In addition, Oil Moisture is measured at 15ppm, Acidity at 0.2 mg KOH/g and oil breakdown at 25kV. This is indicative of degradation and accelerated ageing, placing the transformer at increased risk of failure.

This example illustrates how the poor condition of a sub-component affects the overall health score.

Initial Health Scores are derived using Steps 1 to 13 from the previous example:

- The Transformer Initial Health Score is **2.90174**
- The Tapchanger Initial Health Score is **2.43382**

Health Score Modifier (see Section 6.8)

The Health Score Modifier for a 33kV transformers is derived in the same generic way as described in Section 6.7 except for the following differences:

- There are three additional Condition Modifiers to the model: The Oil Test Modifier, the DGA Test Modifier and the FFA Test Modifier.
- The parameters used to combine the Factors associated with these Condition Modifiers in order to derive the Health Score Factor are as shown in Table 10.

14. The Oil Test modifier is determined from EQ. 22

$$\text{Oil Condition Score} = 80 \times \text{Moisture Score} + 125 \times \text{Acidity Score} + 80 \times \text{Breakdown Strength Score}$$

Using the inputs determined from Table 203 - Table 205 as follows:

Oil Condition Score = (80 x 2) + (125 x 4) + (80 x 10) = 1,460 giving an Oil Test Factor of **1.2** and an Oil Test Collar of **5.5** in accordance with Table 206 and Table 207 respectively.

15. The DGA Test modifier is determined from EQ. 23, EQ. 24 and EQ. 25

$$\text{DGA Score} = 50 \times \text{Hydrogen Score} + 30 \times \text{Methane Score} + 30 \times \text{Ethylene Score} + 30 \times \text{Ethane Score} + 120 \times \text{Acetylene Score}$$

$$\text{DGA Test Collar} = \text{DGA Score} \div 220$$

$$\%\ \text{Change} = \frac{\text{DGA Score}_{\text{latest}} - \text{DGA Score}_{\text{previous}}}{\text{DGA Score}_{\text{previous}}} \times 100\%$$

Using the inputs determined from Table 208 - Table 212:

- Current DGA Condition Score = (50 x 4) + (30 x 4) + (30 x 4) + (30 x 4) + (120 x 4) = 1,040
- Previous DGA Condition Score = (50 x 0) + (30 x 0) + (30 x 0) + (30 x 0) + (120 x 2) = 240
- % change = ((1,040 – 240) / 240 x 100) = 333% giving a DGA Test Factor of 1.50 in accordance with Table 213 and Table 214.
- The DGA Test Collar = 1,040 / 220 = 4.727273

16. The FFA Test modifier is determined from Table 215 to give an FFA Test Factor of 1.0
17. The Health Score Factor (pre collar) can therefore be determined using the MMI technique as follows: 1.5 + ((1.2-1.0) / 1.5) = 1.6333

<u>Current Health Score (see Section 6.1.7)</u>

18. The Health Score Modifier is calculated using the MMI technique described in Section 6.8.
19. The Transformer Current Health Score is given by EQ. 7 as

$$\text{Current Health Score} = \text{Initial Health Score} \times \text{Health Score Factor} \times \text{Reliability Factor}$$

giving **2.90 x 1.633 = 4.73950**

20. The test conditions in EQ. 8 and EQ. 9 confirm that this value is outside the cap and collar range (5.5 to 10) due to the DGA Test Collar and so the Transformer Current Health Score becomes **5.5.**
21. The Tapchanger Current Health Score is similarly given by EQ. 7 as **2.43 x 1 = 2.43**. EQ. 8 and EQ. 9 confirm that this value is within the cap and collar range (0.5 to 10), so the Tapchanger Current Health Score is confirmed as **2.43**
22. The combined Current Health Score is derived according to Section 6.2 as **MAX(5.5, 2.43) = 5.5**
23. The corresponding Health Index Band is given by Table 5 as **HI3**

The derivation of the PoF and Future Health Score then follows the same pattern as described in Steps 15-22 in the first example

F.2 Consequences of Failure

The described methodology is capable of representing a very wide range of asset criticalities. In order to provide the reader with some clarity, this section works through a selection of typical scenarios. The scenarios presented here are not exhaustive but provide an illustration of how the methodology works.

Example 1: A distribution RMU with a typical number of connected customers

The asset used in this example is an 11kV oil-filled RMU supplying 800 customers with normal access arrangements. The safety location and type risks have been assessed as "Medium" in accordance with ESQCR. It is moderately close to a water course. For this asset, the following calculation steps enable the Consequences of Failure to be determined:

<u>Financial Consequences (see Section 7.3)</u>

1. Table 16 "Reference Costs of Failure" gives the Reference Financial Cost of Failure as **£9,839**
2. Table 221 "Access Factor: Switchgear & Transformer Assets" gives the Access Factor as **1**
3. Applying EQ. 28 and EQ. 29

$$\text{Financial Consequences of Failure} = \text{Reference Financial Cost of Failure} \times \text{Financial Consequences Factor}$$

$$\text{Financial Consequences Factor} = \text{Type Financial Factor} \times \text{Access Financial Factor}$$

gives the Financial Consequences of Failure as **£9,839 x 1 = £9,839**

<u>Safety Consequences (see Section 7.4)</u>

4. Table 16 "Reference Costs of Failure" gives the Reference Safety Cost of Failure as **£4,823**
5. Table 225 "Safety Consequence Factor – Switchgear, Transformers & Overhead Lines" gives the Safety Consequence Factor as **1**
6. Applying EQ. 31

$$\text{Safety Consequences of Failure} = \text{Reference Safety Cost of Failure} \times \text{Safety Consequences Factor} \times \text{Safety Risk Reduction Factor}$$

gives the Safety Consequences of Failure as **£4,823 x 1 = £4,823**

<u>Environmental Consequences (see Section 7.5)</u>

7. Table 16 "Reference Costs of Failure" gives the Reference Environmental Cost of Failure as **£1,486**
8. Table 229 "Type Environmental Factor" gives the Type Environmental Factor as **0.98**
9. Table 231 "Location Environmental Factor" gives a Proximity Factor of **1** and a Bunding Factor of **1**. The Location Environmental Factor is therefore equal to **1**

10. Applying EQ. 33 and EQ. 34

$$\text{Environmental Consequences of Failure} = \text{Reference Environmental Cost of Failure} \times \text{Environmental Consequences Factor}$$

$$\text{Environmental Consequences Factor} = \text{Type Environmental Factor} \times \text{Size Environmental Factor} \times \text{Location Environmental Factor}$$

gives the Environmental Consequences of Failure as **£1,486 x 0.98 = £1,456**

<u>Network Performance Consequences (see Section 7.6)</u>

11. Table 16 “Reference Costs of Failure” gives the Reference Network Performance Cost of Failure as **£11,580**
12. Applying EQ. 38 and EQ. 39

$$\text{Network Performance Consequence Factor} = \text{Customer Factor} \times \text{Customer Sensitivity Factor}$$

$$\text{Customer Factor} = \frac{\text{No. of Customers}}{\text{Reference No. of Customers}}$$

gives the Network Performance Consequence Factor as **800 / 1,000 x 1 = 0.8**

13. Applying EQ. 37

$$\text{Network Performance Cost of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Network Performance Consequence Factor}$$

gives the Network Performance Cost of Failure as **£11,580 x 0.8 = £9,264**

<u>Consequences of Failure (see Section 7.1)</u>

14. Figure 20 “Consequences of Failure” shows that the total Consequences of Failure is the sum of the above, giving **£9,839 + £4,823 + £1,456 + £9,264 = £25,382**

As described in Section 5.3 the classification of this total CoF into Criticality Bands C1, C2, C3 and C4 is a based on the relative magnitude of the total CoF of the asset (in this instance £25,382) compared to the Reference Costs of Failure shown in Table 16(in this instance £27,728) and the Criticality Index banding criteria shown in Table 6. Therefore, in this example, **£25,382 / 27,728 = 92%** giving a Criticality Index band of C2.

Example 2: A distribution RMU with a single commercial customer

The asset used in this example is an 11kV oil-filled RMU supplying a single commercial customer 600kVA of load and normal access arrangements. The safety location and type risks have been assessed as “Medium” in accordance with ESQCR. It is not close to a water course. For this asset, the following calculation steps enable the Consequences of Failure to be determined:

Steps 1 to 10 are exactly the same as in the previous example.

<u>Network Performance Consequences (See Section 7.6)</u>

11. Applying Table 18 “Customer Number Adjustment for LV & HV Assets with High Demand Customers” gives the multiplier on the number of customers as **250**
12. Applying EQ. 38 and EQ. 39

$$\text{Network Performance Consequence Factor} = \text{Customer Factor} \times \text{Customer Sensitivity Factor}$$

$$\text{Customer Factor} = \frac{\text{No. of Customers}}{\text{Reference No. of Customers}}$$

gives the Network Performance Consequence Factor as **250 / 1,000 x 1 = 0.25**

13. Applying EQ. 37

$$\text{Network Performance Cost of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Network Performance Consequence Factor}$$

gives the Network Performance Cost of Failure as **£11,580 x 0.25 = £2,895**

<u>Consequences of Failure (see Section 7.1)</u>

14. Figure 20 “Consequences of Failure” shows that the total Consequences of Failure is the sum of the above, giving **£9,839 + £4,823 + £1,456 + £2,895 = £19,013**

As described in Section 5.3 the classification of this total CoF into Criticality Bands C1, C2, C3 and C4 is a based on the relative magnitude of the total CoF of the asset (in this instance £19,013) compared to the Reference Costs of Failure shown in Table 16(in this instance £27,728) and the Criticality Index banding criteria shown in Table 6. Therefore, in this example, **£19,013 / 27,728 = 69%** giving a Criticality Index band of C1.

Example 3: An EHV transformer with typical loading

The asset used in this example is a 33/11kV, 24MVA-rated transformer with normal access arrangements. The safety location has not been assessed. It is bunded and moderately close to a water course. It has a maximum demand of 10MVA and is in an “n-1” (or Secure) configuration. For this asset, the following calculation steps enable the Consequences of Failure to be determined:

Financial Consequences (see Section 7.3)

1. Table 16 “Reference Costs of Failure” gives the Reference Financial Cost of Failure as **£87,698**
2. Table 219 “Type Financial Factors” gives the Type Financial Factor as **1.1**
3. Table 221 “Access Factor: Switchgear & Transformer Assets” gives the Access Factor as **1**
4. Applying EQ. 28 and EQ. 29

$$\text{Financial Consequences of Failure} = \text{Reference Financial Cost of Failure} \times \text{Financial Consequences Factor}$$

$$\text{Financial Consequences Factor} = \text{Type Financial Factor} \times \text{Access Financial Factor}$$

gives the Financial Consequences of Failure as **£87,698 x 1.1 x 1 = £96,468**

Safety Consequences (see Section 7.4)

5. Table 16 “Reference Costs of Failure” gives the Reference Safety Cost of Failure as **£23,502**
6. Table 225 “Safety Consequence Factor – Switchgear, Transformers & Overhead Lines” gives the Safety Consequence Factor as **1**
7. Applying EQ. 31

$$\text{Safety Consequences of Failure} = \text{Reference Safety Cost of Failure} \times \text{Safety Consequences Factor} \times \text{Safety Risk Reduction Factor}$$

gives the Safety Consequences of Failure as **£23,502x 1 = £23,502**

Environmental Consequences (see Section 7.5)

8. Table 16 “Reference Costs of Failure” gives the Reference Environmental Cost of Failure as **£17,048**
9. Table 229 “Type Environmental Factor” gives the Type Environmental Factor as **1**
10. Table 230 “Size Environmental Factor” gives the Size Environmental Factor as **1.6**
11. Table 231 “Location Environmental Factor” gives a Proximity Factor of **1** and a Bunding Factor as **0.5**. The Location Environmental Factor is therefore equal to **1**
12. Applying EQ. 33, EQ. 34 and EQ. 35

$$\text{Environmental Consequences of Failure} = \text{Reference Environmental Cost of Failure} \times \text{Environmental Consequences Factor}$$

$$\text{Environmental Consequences Factor} = \text{Type Environmental Factor} \times \text{Size Environmental Factor} \times \text{Location Environmental Factor}$$

$$\text{Location Environment Factor} = \text{Proximity Factor} \times \text{Bunding Factor}$$

gives the Environmental Consequences of Failure as **£17,048 x 1 x 1.6 x 0.5 = £13,638**

Network Performance Consequences (see Section 7.6)

13. Table 16 “Reference Costs of Failure” gives the Reference Network Performance Cost of Failure as **£28,940**
14. Applying EQ. 42

$$\text{Load Factor} = \frac{\text{Actual Load Supplied By Asset}}{\text{Maximum Demand Used To Derive Reference Network Performance Cost of Failure}}$$

gives the Load Factor as **10 / 15 = 0.66**

15. Applying EQ. 41

$$\text{Network Performance Consequences of Failure} = \text{Reference Network Performance Cost of Failure} \times \text{Load Factor} \times \text{Network Type Factor}$$

gives the Network Performance Consequence of Failure as **£28,940 x 0.66 x 1 = £19,100**

Consequences of Failure (see Section 7.1)

16. Figure 20 “Consequences of Failure” shows that the total Consequences of Failure is the sum of the above, giving **£96,468 + £23,502 + £13,638 + £19,100 = £152,708**

As described in Section 5.3 the classification of this total CoF into Criticality Bands C1, C2, C3 and C4 is a based on the relative magnitude of the total CoF of the asset (in this instance £152,708) compared to the Reference Costs of Failure shown in Table 16(in this instance £157,188) and the Criticality Index banding criteria shown in Table 6. Therefore, in this example, **£152,708 / 157,188 = 97%** giving a Criticality Index band of C2.