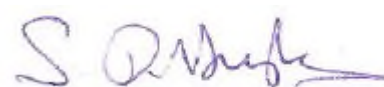


**Construction
Design Handbook**

GUIDANCE FOR ENGINEERING ASSURANCE ENGINEERS

DH 24

Issue 2



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Technical Assurance Manager

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GUIDANCE FOR ENGINEERING ASSURANCE ENGINEERS

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1 INTRODUCTION

1.1 General Information

All National Grid Electricity Construction schemes are subject to the provision of Engineering Assurance throughout the various project stages as defined within the associated Network Development Process document. The purpose and terms of reference for Engineering Assurance are fully detailed in Transmission Procedure TP188.

1.2 Purpose and scope

This document will define in general terms the principal activities associated with Engineering Assurance, focussing on the specific tasks to be undertaken. The document is provided for guidance only and should be viewed as an “aide memoire” to the practising assurance engineer.

The guide has been updated to reflect recent changes in both the Network development process and contracting strategy. The key focus of this handbook remains unchanged in that assurance engineers are asked to implement a risk based strategy concentrating on key issues or on areas of design that have traditionally caused problems for scheme delivery. Throughout all project stages the assurance engineer is expected to actively engage with both internal and external stakeholders and the delivery organisations to ensure that;

- ❖ a mutually agreeable design is tabled at each project stage with a clearly defined schedule of deliverables.
- ❖ the extent and detail of documentation and drawings meets the requirements of the project stage.
- ❖ an acceptable design development and delivery programme is agreed allowing sufficient time for review, agreement and amendment as required

1.2 Reference Documents

This design handbook should be read in conjunction with the following National Grid documentation:

- ❖ TP 500 - Network Development Process (and its related key documents)
- ❖ TP 188 - Design Management
- ❖ TP 141 - Design Authorisation / Assessments

2 PROJECT ENGINEERING ASSURANCE

2.1 Assurance General Requirements

2.1.1 Assurance Philosophy

This is a consenting process by which National Grid formally states by acceptance of key design related documentation during the early project stages and by completion of a Design Compliance Audit Assurance Report (DCAAR) at the Project Execution stage, that detailed design/construction/installation may (or may not) proceed in accordance with the submitted design

This does not mean National Grid has fully checked any part of a particular design and it is not a design approval process. A successful assurance submission simply confirms that National Grid has no objection to the related site work commencing on the basis that, following a review, there is no known reason why it shouldn't.

The starting premise for each assurance engineer shall be that the submitted design is correct unless proven otherwise. In other words the in-house quality management systems of the organisation having contractual responsibility with National Grid for the design, plus the additional governance requirements mandated in TP188 (i.e. Contractor Design Approval) have, in combination, produced a fully compliant design. Engineering Assurance does not replace or support these second party design responsibilities and is a separate, stand alone client side undertaking.

The key task of the assurance engineer therefore is to enact selective, risk based inspections to support and facilitate this consenting process. These are carried out specifically in relation to the drawings, schedules and other documents used on site for construction/installation purposes and whilst it might be necessary to view other supporting information (e.g. calculations, surveys, condition assessments etc) to achieve this objective the consenting process does not extend to such information.

The Assurance Engineer shall be required to use the knowledge and skill pertaining to their particular technical discipline to support the Lead Assurance Engineer in developing a strategy for the assurance on a particular project. This strategy shall determine the scope of their assurance activities and the design inspections carried out within that relevant scope shall be assumed to be representative of the design as a whole. Consequently the design may be accepted or rejected via the appropriate DCAAR on this selective basis noting that the latter outcome shall result in a review and possible widening of the assurance scope. The Assurance Engineer shall identify any areas of specialist design (outside of their knowledge and skill) and ensure that this is adequately covered as required by suitably qualified design specialists.

Although completion of the DCAAR is a specific task only required once the design has been formally submitted the assurance engineer shall ensure they are actively involved in the design production process via all formal and, where appropriate, informal project communication channels. In the main they will be expected to be sufficiently familiar with the design philosophy and supporting decisions and activities that the formal submission presents no surprises and thus completion of the DCAAR is largely a procedural formality.

2.1.2 Temporary Works and Engineering Assurance

Where required by TP184, temporary works design shall be submitted for assurance in accordance with TP188. A review of the supporting calculations and other technical documents is not excluded from the scope of the Engineering Assurance engineer's responsibilities however, because of the specialist and wide ranging nature of temporary works schemes this responsibility shall focus more on procedural, rather than technical,

compliance, i.e. greater reliance may be placed on the competency of the contractor organisation.

The Assurance Engineer shall, as a minimum, be expected to confirm the following TP184 design related requirements;

- ❖ An authorised Temporary Works Co-ordinator and, if necessary, Temporary Works Supervisor have been appointed,
- ❖ The Temporary Works Schedule is appropriately completed,
- ❖ An appropriate Design Brief has been prepared,
- ❖ An appropriate Design Check Category has been identified,
- ❖ An appropriate Independent Design Check has been carried out, ensuring that for category 2 & 3 checks the checker has not been provided with the original calculations,
- ❖ All drawings & other documents for site use are marked 'for construction' or similar and are appropriately cross-referenced on the procedural forms

The scope of engineering assurance does not extend to TP184 procedural compliance of site activities, for example completion of a 'permit to load'.

Whilst temporary works is largely associated with civil engineering activities it is not exclusive to them and consequently the assurance task in this respect may be enacted by any authorised designer of whichever discipline is related to the Temporary works need case.

2.1.3 Generic Key Tasks

A number of tasks can be considered as generic or as common duties to be performed by the Engineering Assurance Engineer during all the respective project stages. It should be noted that some of these activities are the responsibility of the Lead Assurance Engineer but the individual discipline assurance engineers are responsible for ensuring design obligations in their area of expertise are completed and communicated to the Lead Assurance Engineer. These generic tasks are detailed below but each scheme should be reviewed against this criterion for completeness;

- ❖ Attend/ support design review meetings as reasonably requested by the both internal stakeholders and the proposed delivery organisation. The Lead Assurance Engineer is to ensure the level of representation at the meeting is appropriate based on the technology requirements of the scheme
- ❖ Confirm the appropriate TP500 related design documents are completed for all engineering disciplines to a consistent standard allowing for a clear and unambiguous understanding of the scope of supply, exclusions, limitations and constraints. For Protection and Control equipment this shall always include identifying the provision of new relays and any proposed reuse
- ❖ Identify unusual operational arrangements or non standard applications. Confirm, in conjunction with developers and designers, that appropriate people within Market Operation, TNCC and Asset Policy (as appropriate) have been involved in discussions and agreements reached

- ❖ Where possible confirm the level of detail associated with a Single Line Diagram has been accepted as appropriate for each particular project stage and that nomenclature has been agreed to the acceptance of all stakeholders including supporting statements from MO and TNCC prior to the project entering the execution stage
- ❖ Review, support and progress (if appropriate) technical deviations in conjunction with developers, designers and Asset Policy
- ❖ Act as the main point of contact for policy, technology and type registration issues
- ❖ Confirm in conjunction with development engineers, designers, ETAM Operations and other stakeholders the buildability and maintainability of any proposals as far as is reasonably practicable
- ❖ Review the high level design philosophy confirming specifications and/or British standards/ Eurocodes exist
- ❖ Ensure design interfaces and overlaps are considered and responsibilities clear between delivery organisations engaged in work on the same scheme/site eg droppers to landing gantries (see DH30) and bulk purchase transformer schemes
- ❖ Agree on the suitability of equipment for reuse. Ensure assessments are to be undertaken in accordance with DH15 and any constraints the agreed reuse of equipment will have on the designs are accepted in principle
- ❖ As far as possible agree scope of equipment supply is exhaustive
- ❖ Ensure design risks are clearly communicated and documented and that where successful scheme delivery is dependent on the use of new technology and Type Registration, the strategy is agreed and accepted at Scheme team level
- ❖ Agree the procedures in place for carrying out assurance on equipment “free issued” to the scheme
- ❖ Identify any specialist assurance requirements. If elements of work are considered outwith the norm, how is assurance to be handled?
- ❖ Where the proposed substation work affects other parties ensure the layout does not compromise their access arrangements or equipment maintainability. Particular examples are on 132KV substation sites with shared bay ownership
- ❖ Ensure the “Connection Agreement “ F4 technical schedule requirements are available, clear and unambiguous.

2.2 Key Assurance Tasks within the Network Development Process

2.2.1 Project Development

The Assurance Engineer shall proactively assist in the technical development of a project as required at the Need Case, Select Option and Develop and Sanction phases of the scheme. He/she will use his/her expertise and judgement in deciding an appropriate level of involvement based on scheme complexity or strategic importance.

NB Clearly smaller schemes, especially those none power system related will not need the same level of support as major infrastructure projects will.

From hereon in, the Need Case, Select Option and Develop and Sanction stages will be referred to as 4.1, 4.2 and 4.3 respectively

The Need Case Stage **(4.1)**- it is not normally envisaged that assurance engineers will be involved at this stage of the process other than for providing some guidance maybe at the “protection solutions” level if the need arises

Select Option Stage **(4.2)** - there may be some involvement with the wider scheme team in preparation of the Project Brief and more specifically with issues associated with technological risks, option viability and outline preparation of the Scheme Design Specification. The assurance engineer may be requested to become involved in preparing and assisting the development engineers with indicative substation layouts and SLD's for feasible options

Develop and Sanction Stage **(4.3)**- the Assurance Engineer will work in close co-operation with the development team to develop the selected option further, to the point where the team considers all the prerequisite technical requirements have been met to an appropriate level of detail. Key to his role at this stage is the effective liaison and day to day involvement with external design/development consultants, survey companies and potentially third party organisations such as DNO's and generators. The nominated lead assurance engineer will ensure that all technical aspects of the Project Execution Plan are completed to his satisfaction and the System Design Specification is signed off.

The Assurance Engineer shall use the discipline specific guidance, contained within this document, as one means of satisfying themselves that fundamental design considerations (those which have a significant bearing on project delivery and sanction costs) have been evaluated.

2.2.2 Project Execution and Delivery

The current contracting model partitions the work of assurance engineers in to 5 key areas in the delivery stage. The work is a natural progression of that done in stage 4.3 so continuity of assurance engineer/s throughout the scheme lifecycle is preferred. We can partition these key areas as follows;

- ❖ Developing the contract “Works Information Pack” in conjunction with the development/delivery team to ensure the tendering technical documentation is complete in every respect and that any indicative drawings/layouts where possible are not product/technology specific.
- ❖ Agreeing to technical aspects of the “Works Information Pack” prior to tender issue and then acting as the single point of contact for all technical queries relating to the scheme, issuing tender amendments and clarifying any scope of supply/interface issues
- ❖ Tender Receipt, Assessment and Contract Award- evaluating tenders received and reconciling tenderers proposal drawings with the drawings issued with the works information. Checking the schedule of deliverables and where applicable their Type Registration status as far as is practicable prior to agreement of the DID with the successful tenderer. Completing internal documentation in support of a contract award.

NB Tender assessment is a significant milestone within the project execution stage. Once again, the assurance engineer shall use the discipline specific guidance as one means of satisfying himself that the tendered design meets both the requirements of the SDS, current NG policy and is sufficiently detailed to form the basis for subsequent development of the Design Intent Document. Where equipment offered is still to be Type Registered, agreement shall be reached with Asset Policy prior to contract award.

- ❖ DID agreement- the assurance engineer shall work with the appointed contractor to develop a detailed design solution in accordance with the requirements of TP188. During this stage the Assurance Engineer shall agree the Design Compliance Audit strategy. See Appendix A
- ❖ Post DID/Project Execution stage- ensure the technical and process obligations defined in TP188 are carried out and manage the Design Compliance Audit process for his discipline. Carry out a detailed review of deliverables as defined within the audit strategy and as appropriate with respect to the discipline specific guidance

2.2.3 Project Review and Closure

The key activity at this stage is to ensure any major outstanding design issues are completed prior to scheme closure. In some circumstances it may be that retrospective design work can only be completed when outages become available at a future date. Should this be the case then the closure process should recognise the requirement for an assurance resource to be allocated to this work.

For all schemes, the following tasks should be considered generic and confirmed as complete by the Lead Assurance Engineer.

- ❖ No significant outstanding work containing design issues to be resolved and/or technical limitations.
- ❖ Asset, operational and technical data has been produced/ revised and made available as required
- ❖ Drawings and manuals have been provided to the occupier. These are site specific and contain any information deemed essential for the lifetime maintenance of the equipment. Specific attention to be paid to non standard equipment and systems
- ❖ Engineering Assurance have been represented at the “Lessons Learned” meeting/ scheme closure meeting

2.3 Discipline Specific Guidance

2.3.1 Key assurance considerations during the Project Development phases

2.3.1.1 Plant and Layout Engineering

The Assurance Engineer shall agree with the development team what drawings and documentation are to constitute the scope/level of detail at this stage. This will be heavily dependent on the specific scheme and the available time scales but as a minimum it is expected the following drawings will be provided for review;

- ❖ Single line Diagram – complete with nomenclature, notional positions of earth switches and where possible portable earthing locations
- ❖ General Arrangement drawing- showing how the new equipment will integrate with equipment on an existing site or how the equipment is to be laid out on a new site
- ❖ Section and elevation drawings- showing access arrangements, design and safety clearances, busbar arrangements ie high to low bars
- ❖ Maintenance access drawing- as part of the above showing indicative method of access. Specific attention is drawn to TS2.1 and TGN(E) 186 with respect to clearances

The Assurance Engineer will satisfy himself that sufficient detail is provided to ensure that;

- ❖ The proposed technology/switchgear solution actually exists.
- ❖ The equipment is suitable for installation in the environmental conditions prevalent on site
- ❖ On GIS sites what are the differences between old and new switchgear if substation extensions are required. Will the point of interface affect existing type registration?
- ❖ The layout of new bays and substation extensions should not compromise access to existing equipment ie crane access to bays containing old ACB's
- ❖ Where the information is available check that the SLD and KLD are consistent with one another
- ❖ Check layouts with TS2.1 standard layout drawings. Agree any departures from the standards with Asset Policy in principle
- ❖ Cable Sealing End compounds - asset replacement work will invariably require that earth switches and surge arrestors need adding. Is there the required space?
- ❖ Banked circuits- ensure additional clearances are built in to the design to facilitate maintenance and isolation with one circuit "in service" if required by the scheme.
- ❖ Overvoltage protection- with specific regard to cables within substations and Hybrid GIS switchgear arrangements check application with the requirements of TGN (E) 27 and Asset Policy. Once a switchgear footprint is agreed any post contract award changes will be costly to accommodate!
- ❖ Where integration of free issue equipment is proposed, ensure that the actual drawings of that equipment ie Shunt Reactor are available and used in the outline engineering.
- ❖ Testing provisions- have reasonable allowances been made for HV testing and HV test equipment. Particular attention should be paid to the testing of HV cables where they terminate to a GIS substation
- ❖ Local conditions- does the site/substation have any history of vandalism or theft. Could this affect the design and equipment to be supplied ie composite insulation and/or stoneguarding?

- ❖ In conjunction with civil design assurance agree the general principles relating to provision of fire damage zones and flood mitigation measures (where applicable)
- ❖ Contribute to discussion on optimising a particular design solution. This is more often appropriate to GIS sites with long GIB runs to AIS line ends.

2.3.1.2 Protection and Control Engineering

- ❖ Check the feasibility of the selected design as specified in the relevant document. Selected options should not introduce high-risk complexity in secondary design (e.g. as a result of a non-standard primary arrangement).
- ❖ Confirm the System Design Specification is complete, including a complete specification of Protection & Control equipment (including identifying provision of new relays and any continued use of existing equipment). This should include the identification of all Substation Control System works either new or system extensions. All required database changes either local or remote to the main site should also be identified. Telecommunication requirements should be considered and Vodafone should have been engaged to identify any communication infrastructure works.
- ❖ Identify unusual operational arrangements and confirm Market Operation are consulted with regard to their documented procedures. If a new control scheme is required, confirm the Functional Requirements Specification (FRS) is available
- ❖ Consider resident special schemes with respect to interfacing to them or possible modification / extension i.e. automatic-switching schemes, operational tripping schemes etc.
- ❖ Confirm the suitability of the main and back up protection coverage as indicated on the SLD by postulating faults at all positions. Particular attention should be paid to Current Transformer (CT) position, overlapping and 'small zone' faults.
- ❖ Consideration should be given to obsolescence or any limitations associated with extendibility. A Substation Control System or Busbar Protection scheme may require additional hardware and modifications to topology if a substation is extended with additional bays. These schemes should be flexible and such modifications should not incur significant additional costs.

2.3.1.3 Cable and Cable System Engineering

- ❖ Confirm that all available relevant geotechnical, geo-environmental and topographical surveys/reports have been taken into consideration (NB: Historic geotechnical and ground contamination reports can be obtained by request from the National Grid Document Controller at Warwick).
- ❖ If applicable, confirm flood mitigation policy has been taken into consideration, and where required confirm a Flood Risk Assessment (FRA) has been undertaken.
- ❖ If applicable, confirm that fire assessments have been made particularly in relation to tunnels and cable basements. A Fire Safety Engineering Solution should have been prepared. (TGN (AR) _005, 'Asset Replacement and Refurbishment' and TS 3.5.12, 'Cable Tunnels and Cable Bridges')

- ❖ Confirm that available relevant Earthing surveys have been taken into consideration, and where relevant, ground return currents are provided.
- ❖ Confirm that the principles of PS (T) EPS12.05 and the guidance contained in TGN (AR) 005 have been applied/adopted in the option selection process.
- ❖ Confirm that the choice of technology, including considerations for tunnel access, comply with current NG policy, PS(T)014.
- ❖ For investments involving installation or refurbishment of fluid-filled cable systems, confirm that the requirements of PS(T)067 for oil systems and sheath bonding are taken into consideration.
- ❖ For investments involving decommissioning of existing cables, confirm NG policy PS(T)093 is applied.
- ❖ Confirm that development/delivery organisation design teams understand the scheme technical requirements. The key requirements to be confirmed at this stage to enable preparation of the cable specification may include, but are not limited to the following:

▪ Rated Voltage ▪ Continuous, Cyclic & Emergency Ratings ▪ 3ph & 1ph Fault Levels ▪ Estimated Route Length (m)	▪ Circuit Identifier ▪ Cable Type (XLPE) & Size(s) ▪ No. of Circuits ▪ No. of cables per phase
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- ❖ Confirm the co-ordination of cable ratings to associated Plant / OHL rating requirements is as per PS (T) 60 or as required by investment team.
- ❖ If applicable, confirm that larger core size or increased cement bound sand (CBS)/stabilised backfill/selected sand has been considered in preference to water cooling (due to long term maintenance requirements).
- ❖ Where a larger conductor size is involved ($>1600\text{mm}^2$) consider use of oxidised / enamelled conductor to achieve the best possible conductor resistance so far as reasonably practicable.
- ❖ Confirm that a schematic block diagram or a line diagram has been prepared to represent the overall scheme cabling works.
- ❖ Confirm that a cable route feasibility study has been undertaken and route specific survey requirements have been identified.
- ❖ Confirm any sections of special engineering installation i.e. Directional Drill / Micro Tunnelling, Cable Bridges & Tunnels, Ventilated Troughs etc that may give rise to SHES and operational risks have been identified and considered.
- ❖ Confirm that potential re-use of assets such as sealing end structures, concrete foundations, concrete surface troughs, tunnels and adits, above ground link boxes and pillar kiosks etc has been considered in accordance with DH15.
- ❖ Confirm 40 year design life for the chosen cable system solution.

- ❖ For refurbishment scheme, confirm consideration has been given to the necessity for advance condition assessment of oil tanks and sealing end platforms.
- ❖ Confirm that provisional requirements for the site establishment, lay down areas, cable drum & accessory storage and working areas are sufficient to enable safe construction have been taken into consideration.
- ❖ Where the information is available check the proposed cable accessories are to be provided from a type registered source. Where new technology or accessories are proposed, liaise with Asset Policy to agree a mutually acceptable acceptance programme

2.3.1.4 Overhead Lines

- ❖ Confirm that all available relevant geotechnical, geo-environmental and topographical surveys/reports have been taken into consideration (NB: Historic geotechnical and ground contamination reports can be obtained by request from the National Grid Document Controller at Warwick).
- ❖ For overhead line refurbishments, confirm all available condition data, surveys/reports have been taken into consideration, including tower, foundations, insulators/fittings, conductor/earthwire Cormon.
- ❖ Confirm that available relevant Earthing surveys have been taken into consideration, and in particular terminal-tower earth bond status/condition.
- ❖ Confirm that the principles of PS(T) EPS12.04 and the guidance contained in TGN(AR) 004 have been applied/adopted in the option selection process.
- ❖ Confirm that evaluation of any options involving oversailing conductors (eg. tees, turn-ins and crossovers) takes into consideration the requirements of PS(T)047.
- ❖ Confirm that the choice of conductor bundle complies with PS(T)046.
- ❖ Confirm that the chosen line design/conductor bundle takes into account any specific EMF or Audible Noise issues.
- ❖ Confirm that the earthwire design (particularly for reduced height towers/non-standard arrangements) takes into consideration PS(T)074.
- ❖ Confirm that the selection of insulator type takes into consideration PS(T)080.
- ❖ Confirm that the chosen overhead line option (new/replacement, refurbishment full or fittings-only) matches the required design life for the investment.
- ❖ Confirm that any specific outage or ERTS requirements have been identified and taken into account in the option selection process.
- ❖ For investments involving decommissioning of existing overhead assets, confirm NG policy PS(T)094 is taken into consideration.
- ❖ Confirm that design teams understand the scheme technical requirements. The key performance requirements to be confirmed at this stage may include, but are not limited to the following:

- Rated voltage
 - Pre- & post-fault ratings
 - Conductor bundle type
 - Operating temperature
 - Fibre-optic requirements
 - Number of circuits
 - Circuit identifier(s)
 - Tower type(s)
 - Route length(s), km
 - Climatic loading requirements
- ❖ Confirm rating philosophy complies with PS(T) 017, in particular confirm any proposals for thermal uprating take into account this policy.
 - ❖ Confirm requirements for Fibre-optic cables, wrap, OPGW etc. For refurbishments consider existing and future requirements, including outage/continuity of service issues.
 - ❖ Confirm any unusual features of existing lines to be worked on, or known to be required for new build (eg. telecoms installations, aircraft warning lights, bird-flight diverters).
 - ❖ Confirm that any non-standard design features of existing lines to be worked on have been identified and considered (eg short insulator strings, over tensioned conductor, non-standard towers).
 - ❖ Confirm that any major obstructions to the OHL route have been identified, including major road/motorway crossings, railway crossing, major/navigable rivers/estuaries, major industrial, commercial or residential developments.
 - ❖ Confirm that a route feasibility study has been undertaken for any new sections of overhead line or towers.
 - ❖ Confirm any special construction techniques (eg Catenary Support, use of Skycradles) envisaged to be used, have been considered in relation to any SHES and operational risks that may arise.
 - ❖ Confirm any route-specific survey requirements have been identified.
 - ❖ Confirm that provisional requirements for the site establishment, lay down areas, conductor drum & fitting storage and working areas are sufficient to enable safe construction have been taken into consideration.
 - ❖ Confirm that a schematic line diagram has been prepared to represent the full overhead line works comprising the investment, including circuit ends, identification of start/end tower numbers, tees, changes of line construction/configuration etc.
 - ❖ Confirm interface issues with other investments have been identified and appropriate actions taken to ensure that the design is joined-up and SHES issues addressed.

2.3.1.5 Civil Engineering

- ❖ Confirm a Flood Risk Assessment (FRA) has been undertaken/or is in progress in compliance with National Grid Flood Mitigation policy. If no FRA is proposed, review the robustness of the supporting argument;