Office for Nuclear Regulation

ONR GUIDE			
Construction Assurance			
Document Type:	Nuclear Safety Technical Assessment Guide		
Unique Document ID and Revision No:	NS-TAST-GD-076 Revision 2		
Date Issued:	September 2015	**Review Date:**	September 2018
Approved by:	T Allmark	Superintending Inspector	
Record Reference:	TRIM Folder 1.1.3.563. 2015/358809		
Revision commentary:	Following a fit for purpose review T/AST/076 issue 1 "Construction Assurance" A replacement TAG will be produced in due course.		

© *Office for Nuclear Regulation, 2015*
If you wish to reuse this information visit www.onr.org.uk/copyright for details.
Published 09/15

Contents

1.0 Purpose and scope

1.1 This TAG contains general guidance and advice to ONR Inspectors on aspects of civil engineering construction assurance.

1.2 Civil engineering construction assurance encompasses the processes/ procedures and cultural aspects necessary to provide the level of confidence that the works are constructed in accordance with the design intent and as required by the safety case and that the materials used and construction methodologies adopted have not undermined the design assumptions made.

1.3 This document is not intended to provide detailed guidance on either the design or construction process, but is produced to highlight certain salient areas for consideration as part of the regulatory process and may be relevant to planned interventions throughout the construction process.

1.4 It should be read in conjunction with other relevant TAG's including but not limited to 'The management for safety ' T/AST/039[1]; Design safety assurance, T/AST/057[2] ; Structural integrity, Civil Engineering aspects, T/AST/017[3] ; Procurement of nuclear safety related items or services , T/AST/077[4].

1.5 This guide is neither prescriptive nor all encompassing. The intention is to highlight typical construction assurance items that a licensee would be expected to address during the design and construction phases of a construction project. Appendix 1, identifies some typical aspects, which an ONR inspector may wish to consider, or seek further specialist opinion on.

1.6 It is to be expected that further assurance may be sought throughout the commissioning, handover and operational phases of a facility. However, this TAG only considers construction assurance up to 'practical completion' by the civil engineering contractor of its works.

1.7 General reference has been made within this guide to issues relating to both quality and design assurance during the design and construction phases, however further information is contained in the following guides for these subject areas:-

- T/INS/17, quality assurance;
- T/INS/19, construction or installation of new plant;
- T/AST/57, design safety assurance.

1.8 The principles described within the above guides are considered 'relevant good practice' to ensure that within the life cycle of a construction project, what is constructed is indeed the physical form of the design intent, and further that both have been executed to a suitable standard, thus ensuring the quality of the product is right for the categorisation and classification of the structure and/or component being considered.

1.9 It is important for the assumptions made by the designer, incorporated within the justification of the design within a safety case, to be properly carried through the construction phase. The final construction of the works is thus as much a part of the safety case as the design.

2.0 Relationship to licence and other relevant legislation

2.1 Licence conditions 14; 17; 19; 20; 22 are the principal relevant licence conditions requiring the licensee to make and implement adequate arrangements.

2.2 Licence condition 14, relating to safety documentation, requires that the licensee "shall make and implement adequate arrangements for the production and assessment of safety cases consisting of documentation to justify safety during the design, construction, manufacture, commissioning, operation and decommissioning phases of the installation."

2.3 Licence condition 17, relating to management systems, requires the licensee to "make and implement adequate quality management arrangements in respect of all matters which may affect safety".

2.4 Licence condition 19, relating to construction or installation of new plant, requires that “Where the licensee proposes to construct or install any new plant which may affect safety the licensee shall make and implement adequate arrangements to control the construction or installation.”

2.5 Licence condition 20, relating to modification to design of plant under construction, requires that “The licensee shall ensure that no modification to the design which may affect safety is made to any plant during the period of construction except in accordance with adequate arrangements made and implemented by the licensee for that purpose.”

2.6 Licence condition 22, relating to modification or experiment on existing plant, requires that “The licensee shall make and implement adequate arrangements to control any modification or experiment carried out on any part of the existing plant or processes which may affect safety.”

2.7 By the very nature of the subject and potential effect on safety there are many other possible relevant licence conditions including LC 26 - control and supervision of operations; LC 25 operational records; LC 12 duly authorised and other suitably qualified and experienced persons.

2.8 The general duties under the health and safety at work act[7], sections S2(1) ; S3(1); S4(1); S4(2) and S6(1)a , impose statutory duties.

2.9 The Construction (Design and Management) Regulations 2007[8], places duties on designers to have “adequate regard to the need:–
“(i) to avoid foreseeable risks to the health and safety of any person at work carrying out construction work or cleaning work in or on the structure at any time, or of any person who may be affected by the work of such a person at work take due recognition of health and safety in the design and implementation process.”

2.10 Section 8(2)a of the Ionising Radiation Regulations[9] also make specific reference to engineering controls and design features, to achieve the restriction of exposure to ionising radiation.

3.0 Relationship to SAP’s, IAEA safety standards, etc

3.1 Reference should be made to the HSE’s safety assessment principles (SAPs)[11] for nuclear facilities together with other relevant technical assessment guides (TAGs) when assessing such design and construction arrangements, processes and procedures. The most relevant safety assessment principles for construction related activities are the civil engineering principles ECE.16 –ECE.19.

3.2 ECE.16: Civil construction materials should be compliant with the design methodologies used, and shown to be suitable for the purpose of enabling the design to be constructed, operated, inspected and maintained throughout the life of the facility.

3.3 ECE.17: The construction should use appropriate materials, proven techniques and approved procedures to minimise the occurrence of defects that might affect the required integrity of structures.

3.4 ECE.18: Provision should be made for inspection during construction to demonstrate that the required standard of workmanship has been achieved,

3.5 ECE.19: Where construction non conformities are judged to have a detrimental effect on integrity or significant defects are detected, remedial measures should achieve the original design intent.

3.6 Other relevant SAP's are, Leadership and management for safety, MS 1-4;Safety classification and standards: ECS 1-3 and Decommissioning: DC 1, 6

3.7 The 2006 SAPs were also benchmarked against the extant IAEA Safety Standards and their main principles are encompassed within the SAPs[11].

3.8 The IAEA Safety Standards GS-R-3 and GS-G-3.1 provide advice on quality management and assurance aspects applicable to construction activities.

3.9 Other relevant guidance can be found in NS-R-1, safety for NPP design; NS-R-3 Site evaluation for nuclear installations , section 6 on quality control; NS-G-3.6 Geotechnical aspects of site evaluation and foundation for NPP.

3.10 WENRA reactor safety reference levels[18] relating to:-
A) Safety policy, S1 Issuing and Communication of a Safety policy (S1.1, 1.5); B) Operating Organisation, S1 Organisational Structure (S1.2,1.3), S2 Management of Safety and Quality (S2.6) , S3 Sufficiency and Competency of Staff (S3.6);
C) Management System, S5 Process Implementation (S5.5, 5.6, 5.7,5.8), S6 Measurement, Assessment and Improvement (S6.4,6.5);
D) Training and Authorisation of NPP staff, S2 Competence and Qualification (S2.1), S3 Training Programmes and Facilities (S3.6), S4 Authorisation (S4.3);
G) Safety classification of structures, systems and components S1 objective (S1.1) , S2 Classification Process (S2.2) , S3 Ensuring Reliability (S3.1), S4 Selection of materials and qualification of equipment (S4.2);
H) Operational Limits and Conditions S1 Purpose (S1.1), are all relevant.

4.0 General advice to inspectors

4.1 This section provides general advice on ONR expectations and potential areas to target during inspection/assessment. More specific advice on some features associated with construction assurance is then given, firstly during the development and design phases of the project (Section 5.1) and then during the construction phase (Section 5.2).

4.2 During both the design and the construction phase's of a project, quality assurance and design assurance are inextricably linked to the issues surrounding construction assurance. A number of existing technical assessment guides are relevant to these specific subject areas and the Inspector should consider the latest available information.

4.3 The following guides are useful initial reference points:-

T/INS/017 – Quality Assurance
T/AST/017 – Structural integrity, civil engineering aspects[3]
T/AST/039 – Management for safety[1]
T/AST/057 – Design safety assurance[2]

4.4 Whilst it is recognised that design organisations may not be the licence holder, both the design and construction process should be under the control of the appropriate licensee acting as an "intelligent customer". SAP's[11] (paragraph 56).

4.5 ONR expects that for construction of a nuclear facility the standards employed are commensurate with the magnitude and nature of the hazard presented by the facility, and are higher than for general industrial design and construction works. Suitable safety categorisation and classification by the licensee should set the requirements for the extent of control and assurance that the design and construction of a facility is subject to.

4.6 Prior to the submission of the Pre Construction Safety Report (PCSR) by the licensee, ONR assessment is more likely to focus on standards and principles being employed, the visibility of optioneering to demonstrate ALARP, and the adequacy of the design process and associated arrangements.

4.7 ONR inspectors need to satisfy themselves that the licensee understands the importance of construction assurance, that appropriate processes have been put in place and that aspects which will provide construction assurance are being given appropriate consideration during the development and design phases of the project.

4.8 The inspector should seek assurance that between: the safety case claims; the civil design substantiation; the specification of the design details and the construction competency of the contractors that the licensee chooses to employ, there is a consistency of purpose.

4.9 In addition confidence needs to be gained that the licensee's construction assurance processes are targeted at achieving an acceptable outcome, so far as can be established during the development and design phases of the project. In particular confidence needs to be gained that the civil engineering designer's intentions will be specified in a manner that can be realised by competent SQEP contractors.

4.10 Following submission of the PCSR but prior to permissioning, the licensee's processes should be fully documented. In addition, activities subject to a permission by ONR should be fully defined. ONR focus at this stage will be towards the technical details, but the licensees systems and procedures must be seen to be capable of delivering the requirements of the design and safety case.

4.11 Following permissioning and commencement of construction ONR focus is more likely to be on management and technical control in order to ensure that the completed installation conforms to the specified requirements. Firstly, to confirm the suitability and sufficiency of all that has been documented as the input to an assured construction process. Secondly, to ascertain those organisations responsible for construction activities fully understand the documented construction information. Thirdly, to confirm by observation that construction is proceeding in a controlled and validated manner, and lastly to gain confidence that the civil engineering structures are being constructed as specified without undermining of any of the design assumptions.

4.12 On-site inspections of construction activities should focus on areas of highest nuclear safety significance where high standards are required and/or on any novel techniques being employed.

4.13 Appendix 1 outlines some specific aspects of civil engineering where inspectors may wish to focus their attention during the construction phase of a project. This is included as an aide memoire for Inspectors but the list is not considered in any way to be definitive or exhaustive.

5.0 Development and Design Phase

5.1 Quality during the design phase

5.1.1‘ Quality assurance and quality control are aspects of good management’[5], in this respect, areas relating to design and subsequent construction need to be appropriately managed to achieve the required quality of the product.

5.1.2 Areas for consideration during the design phase may include, but not be limited to: -

- Organisations and the communications between them
- Staffing and training , including SQEP evaluation
- Document control, including preparation, review , approval and change control
- Design control, including interfaces, verification, validation and changes
- Procurement control, including supplier evaluation and selection, control of items and services purchased

Reference should be made to T/INS /017 on Quality Assurance.

5.2 Design categorisation and classification

5.2.1 Structures, systems and components (SSC) should be designed and specified to provide the required engineering functionality. This functionality will have an influence on safety and so requires an appropriate safety category to be assigned.

5.2.2 ONR expectation is that the processes and procedures considered should be to an appropriate level dependent upon the categorisation and classification being applied.

5.2.3 Categorisation and classification will affect:-

- the design methods used and their extent;
- the standards to be used;
- the material selections made;
- the procurement processes used;
- the methods of fabrication and installation;

- the extent and type of inspections as well as maintenance requirements and in- service inspections proposed.

5.3 Codes and standards

5.3.1 Whilst BS and Euro EN codes, (including nationally determined annexes) may not be specifically written with nuclear facility designs in mind, it is noted that they may form the base understanding of the contractor in terms of control of materials, workmanship, durability, tolerances, testing and inspection regimes.

5.3.2 It is customary in the UK nuclear industry for designers to utilise other international or USA codes as part of the design process. These may also be supplemented or replaced entirely by the licensees own standards. Differences in dimensional or other units may emanate from foreign designs and this aspect may well require further consideration.

5.3.3 It is therefore important to recognise that codes may set standards and requirements for construction details, workmanship, concrete mix design, reinforcement and fixing details, material specifications and in the case of the EN codes, options for control of construction which may be unfamiliar to a UK construction work force.

5.3.4 Care needs to be exercised at the detailed design stage that appropriate account is taken of these aspects ensuring that the design intent is carried through as anticipated during the construction process. Appendix 1 provides some examples where the design intent may not be met unless the requirements are clearly communicated by the designer to the contractor.

5.3.5 The contract drawings, schedules and construction specification should include all design, workmanship, inspection and testing requirements to be fulfilled during the construction process. However, it would also be expected that the designer highlights areas to the contractor that might not represent ‘normal’ practice in order to establish the practicality of the proposal and ensure the contractor understands the full requirements.

5.3.6 In addition the licensee should have sufficient capability to understand such issues and their bearing on safety and fulfil the role of an intelligent customer. Refer to T/AST/049[21].

5.4 Material use

5.4.1 International codes tend to base design on the materials available within the country of origin. These materials may not be the standard / readily accepted / readily available norms in the UK, for example reinforcing bar yield strengths.

5.4.2 Useful information may be obtained from the relevant industry bodies such as CARES[22] for rebar, BCSA[31] for steel construction, IMS[32] for masonry.

5.4.3 The designer needs to specify materials (for instance reinforcement bars) that will meet the relevant structural requirements in a manner that is acceptable to the contractor. Failure to communicate and agree with the contractor these requirements will lead to formal design change requests later. Changes in materials subsequent to the completion of the design should be kept to a minimum as determining the implications for the design can require multi disciplinary specialist knowledge and if there are numerous design changes there is a risk that the specialists may not be aware of all the changes when making a decision.

5.5 Codes and testing requirements

5.5.1 International / USA codes[13,23,24,25] such as American Institute of Steel Construction (ANSI/AISC 360) Specification for structural steel buildings[23] or American Concrete Institute (ACI 349)[13] Code requirements for nuclear safety related concrete structures, may base the design on differing forms of test results and requirements . For example the use of cylinder compressive strengths instead of cube compressive strengths (see also Appendix 1).

5.5.2 ONR expectation is that the principal contractor / contractor should be fully conversant with the relevant codes used and further that suitably qualified and experienced personnel (SQEP) are employed in the relevant site supervisory roles. An Inspection and Test Plan (ITP) should be agreed with the licensee.

5.6 Alignment of the civil engineering design and safety case

5.6.1 The PCSR should document how operational and safety functional requirements have been derived and communicated to the civil engineering designer in a clear manner.

5.6.2 The designer's requirements are generally communicated to the contractor through the contract drawings, schedules and construction specification. It is expected that these documents would include all design, workmanship, inspection and testing requirements to be fulfilled during the construction process.

5.6.3 It is an ONR expectation that the designer and contractor engage in early dialogue regarding the methods to be used, the design intent and possible contractor 'optioneering'. This is considered an important stage in the early communication of both the design and the assumptions made during the design to fulfil the safety case justification.

6.0 Construction Phase

6.1 Quality during the construction phase

6.1.1 The general information on quality assurance and quality control presented in section 5.1.1 during the design is also applicable during the construction phase. Areas for consideration during the construction phase may include, but not be limited to: -

- Site control, including identification and control of materials, parts and components, handling storage and shipping
- Process control; including planning, procedures, permits, hold points, method statements
- Inspection, monitoring and testing
- Non conformance control
- Corrective actions, including close out and verification

- Records, including as designed and as constructed, maintenance and operational manuals

6.2 Forms of contract

6.2.1 It is an ONR expectation that criteria should have been set by the licensee for selection of the most appropriate form of contract[33]. The selection criteria should take into account the potential impact of administering and applying the contract on the quality of the outputs from the contract where such outputs affect nuclear safety.

6.2.2 Some factors affecting the quality of outputs may include:

- Commercial pressures (for example in fixed price lump sum contracts, particularly in the delivery of complex safety related designs or components)
- Impact of the prescription of an overly-challenging contract programme
- Suitability of the contract in relation to the maturity of the data that is to be used as input to the contract.

6.3 Supply chain management

6.3.1 Control and monitoring of contractors may be made more difficult by increases in the length of a supply chain. Even with ‘back to back ‘contracts the original design philosophy and assumptions can be lost or misunderstood through distance from the original intent.

6.3.2 A further complication may exist in the control / verification of SQEP personnel and the overall quality by the licensee of the manufacture and supply of safety related components or designs. For example, when significant design is included in ‘design and build’ forms of contract the design element of the contract may be further subcontracted thus becoming increasingly more remote within a supply chain.

6.3.3 It is an ONR expectation that a similar standard of quality assurance as applied by the licensee is evident and verifiable throughout the supply chain for nuclear safety related items. It is also expected that supply chain lengths are minimised as much as practicable.

6.3.4 Safety culture and safety awareness is as important as verifiable documentary form filling. Contractors would also be expected to exhibit a safety culture and safety awareness with a ‘questioning attitude’ similar to that of the licensee.

6.4 Design assumptions – verification

6.4.1 During the design certain assumptions may be made. For example, assumptions based on ground investigation data obtained. However, site conditions in actuality may vary. Examples such as:

- Varying ground water levels
- Settlement
- Anomalies in ground conditions from those expected from ground investigations
- Unforeseen Services

It is important therefore that the design team are apprised of site conditions found during the construction.

6.4.2 The use of approved contractor method statements, hold point control plans, permits to dig can also be a useful means of reviewing design assumptions.

6.4.3 It is an ONR expectation that a comprehensive quality management system should be implemented that allows the full implications of site issues to be considered against the original design assumptions, ensuring the design intent is carried through the construction process.

6.4.4 Of particular importance is a process whereby it is demonstrated that the contractor's methods and materials are capable of delivering the designer's intentions, especially when nuclear safety is dependent on non-standard construction methods and materials. Construction assurance and the necessity to demonstrate ALARP means that there should be a culture of continuous improvement and to this end it would be expected that construction reviews would be undertaken during the construction process.

6.5 Suitably qualified and experienced people SQEP

6.5.1 The importance of utilising the 'right' people, with the 'right' level of understanding and knowledge at the 'right' time should not be underestimated.

6.5.2 It is an ONR expectation that suitably qualified and experienced personnel (SQEP) in accordance with licence condition LC 12 are used at every level and that pre- training prior to contract is considered where appropriate. Reference should also be made to ONR guidance T/INS/012[17], DAP's and SQEP's.

6.5.3 It is an ONR expectation that all SQEP records should be kept up-to-date throughout the duration of a project and at all levels throughout the supply chain.

6.6 Communication

6.6.1 Good, clear, timely communication between individuals, teams and companies is important. Clear lines of communication and expectations are all part of a quality culture. Good communication is vital and it is an ONR expectation that a construction project should have systems in place that reflect this requirement. This requirement should extend to all parties involved and at all levels including communications between the contractor and the designer. Co- located project offices should be considered as a means of facilitating communication.

6.7 Design changes

6.7.1 It is recognised that changes to the design may arise from various sources and for a variety of reasons during the construction process. It is ONR's expectation that the licensee, together with the design and construction teams, should operate rigorous systems to capture, record, justify and implement any proposed changes, however they are initiated.

6.7.2 The systems and procedures used should allow a suitably qualified and experienced person (SQEP) to decide on the implications of each proposal and permit them to be fed back to the relevant members of the design team for consideration and agreement to the change, as necessary.

6.7.3 Construction on a licensed site is subject to LC 20 – modification to design of plant under construction, and appropriate safety classification arrangements are required.

6.8 Non conformances

6.8.1 During the construction process non-conformances may occur. It is important that there are appropriate procedures and processes within the project team to record non-conformances and confirm the actions taken through the design team to address any issues resulting from a non-conformance.

6.8.2 It is ONR's expectation that the licensee, designer and contractors should have a suitable system for recording and dealing with all non- conformances.

6.8.3 A site culture should be engendered, such that contractors are positively encouraged to report openly any potential non-conformances no matter how they have arisen. Generally, a 'questioning attitude' should be fostered within the construction team.

6.9 Certification of materials

6.9.1 In a modern global market, materials and components may not originate in the EU but may be sourced from around the world. Whilst this brings with it certain benefits it can also bring challenges ranging from the provision of false certification covering dubious quality control in manufacture to a lack of real auditable / traceability of components through to counterfeit parts entering the supply chain. This lack of an auditable quality trail means that the specification may be compromised, threatening any claims made in the safety case.

6.9.2 It is ONR's expectation that batch traceability of all materials should be available and for high integrity items, component traceability should also be available. The licensee should also consider verification testing by third party of certain high safety significance items.

6.10 Contractor self certification

6.10.1 "Certification by the work originator of the design and construction of structures whose failure would not have high consequences can give adequate assurance of structural safety provided there are appropriate systems in place for ensuring competence"[14].

6.10.2 However, for safety critical items of plant or nuclear related construction processes whose failure would have high consequences, third party independent certification should be used to give added assurance of structural / nuclear safety. An appropriate level of checks and certification should be found within these two extremes.

6.10.3 Whilst quality cannot be inspected into the construction process it is an ONR expectation that the licensee's arrangements should include additional supervision and management systems to control the construction activity of nuclear related construction and reduce risks to nuclear safety.

6.10.4 It is an ONR expectation therefore that the certification of structural nuclear safety related work should thus only be entrusted to appropriately qualified and experienced people.

6.10.5 Reference to licence condition LC 12 concerning duly authorised and other suitably qualified and experienced persons should also be made.

6.11 Third party assurance

6.11.1 ONR's expectation is that appropriate quality systems should be applied as necessary throughout all levels of a project supply chain in accordance with licence condition LC17. Refer also to T/INS/017[28].

6.11.2 Given the potential scale of some projects it is possible that construction consortiums may be envisaged. This process may lead to project teams working to a conglomerate of systems. Whilst parts may be familiar to certain members of the team, other parts are not. This interface needs to be recognised, understood, planned and managed such that an effective, efficient quality plan is produced.

6.12 Contractor selected materials

6.12.1 It is ONR's expectation that a suitable contractor proposed material approval system should be implemented by the licensee. Material selection by the construction team within the specification should be verified by the original designer against the original design intent as translated into the specification and hence against any claims on the safety case and validated as such.

Reference should also be made to the Construction (Design and Management) Regulations and associated ACoP[29] in relation to designers.

6.13 Testing, monitoring and inspection

6.13.1 It is ONR's expectation that the use of hold points for certain testing and or inspections should be considered. Requirements should be clearly stated in the specification and should incorporate standards appropriate to the categorisation and classification of the structure, system or component. The requirements should be incorporated into agreed test and inspection plans, and hold point control plans, which have been integrated within the risk management process and programme. The use of approved contractor method statements may also act as a hold point and control over works on site. Refer also to IAEA NS-G-3.6[30] ; Section 2, site investigation; Section 4, consideration for foundations; Section 7, monitoring of geotechnical parameters, for further details relating specifically to site investigation.

6.14 As-constructed records

6.14.1 “As-constructed records have in the past received various levels of attention at the end of a project. Records management and retention is often found to be an area for poor practice or sometimes records not available due to the time delays in their production”[8].

6.14.2 It is ONR’s expectation that as-constructed records should provide a fully referenced account of the work actually constructed and should be produced in a timely manner as the information becomes available throughout the contract.

6.14.3 General progress photographs may be useful during the construction phase but will generally be inadequate for more detailed recording of ‘as-constructed’ items.

6.14.4 However, for the purposes of verification of construction detail, particularly areas which cannot be readily inspected, will become inaccessible, concealed or covered once complete, it is ONR’s expectation that detailed referenced photographs should be retained and used as part of the as-constructed records. As-constructed records are an important aspect of future verification and maintenance and as such suitable and adequate provision should be made for their retention.

6.15 Modular design elements

6.15.1 The use of modular design elements and precast units manufactured off site can have benefit in terms of quality, time/ programme but bring with them potential problems. There is an increasing tendency to make such elements as large as possible. Problems of long periods in storage; haulage; transport across site; craneage; and incorporation details should all be considered both in the design and within the risk management plan and be part of an agreed and considered construction philosophy and methodology.

6.15.2 It is ONR’s expectation that early dialogue between the designer and contractor should occur to discuss elements of the construction process and how this can be best achieved.

6.16 Barriers to understanding

6.16.1 Barriers to understanding may arise through foreign companies entering the UK market. This could include both design houses or design teams working abroad and foreign contractors working in the UK.

6.16.2 “With construction companies carrying fewer of their own operatives, there tends to be a heavy reliance on labour only (LO) subcontract organisations.

Many of these organisations have a diverse workforce. Language barriers are common within these workforces, giving challenges in the communication of health and safety requirements during site induction and toolbox safety talks”[15].

6.16.3 The use of global workforces may reduce the level of ownership and commitment, fragmenting the quality culture ethos that is necessary within the workforce.

6.16.4 It is ONR expectation that a robust system of checks to understanding should be incorporated into both induction and toolbox talks relating to health, safety and construction quality issues and that relevant SQEP supervisory staff are employed.

6.17 Performance indicators

6.17.1 The selection of inappropriate performance indicators either key performance indicators (KPI's) or safety performance indicators (SPI's) can produce a negative culture.

6.17.2 It is ONR's expectation that careful consideration should be given to the selection and use of relevant indicators and their effect on the drivers for the project. Evidence of monitoring the effects of KPI's / SPI's over time should be used.

6.18 Demolition / decommissioning

6.18.1 Reference should be made to the Safety Assessment Principles (SAP's)[11], Safety principles DC 1-8 together with the relevant guidance.

6.18.2 CIRIA report T 30.001 Demolition, Dismantling and Decommissioning Rev 03 [Jan 09][19] may also be a useful guide on aspects of demolition.

6.18.3 It is ONR's expectation that decommissioning and demolition of structures should be considered during the planning, design, construction and operational stages and in line with licence Condition LC 35 and the CDM regulations[8].

Appendix 1 - Areas of Construction and Expectations

The following table provides areas of civil engineering related to new construction works, which inspectors may wish to use as a prompt for further consideration and thought. This list is not meant to be exhaustive.

Area for consideration	Attribute	Importance	Additional Notes
Concrete	Strength	Design based on specified strength. Excessive over or under strength will affect performance	Specifications to set limits
	Additives, including cement replacement	May affect long term strength, change performance and affect durability	Specification to set limits and types. Refer to Line to Take
	Joints (Construction / Movement)	Affect load transfer. Affect containment. Affect shielding	Specify appropriate detail. Specification to reflect design code requirements on workmanship
	Shrinkage, construction sequence (related Issues)	Can affect shear performance. Cracks may need to be sealed to prevent contamination ingress/transfer	Designer to specify or contractor to agree with designer
	Shielding (high density concrete)	Placing and compaction difficulties	Designer to specify or contractor to agree with designer
Concrete	Surface finish	May be important for control of contamination/ application of decontaminable surfaces. Durability, Location of form ties	Specification to set standards
	Certification	Long term records for verification of construction standards. Will be relevant also for PRS as well as initial licensing	LC 6 arrangements
Seismic Gaps	Seismic gap dimensions should be set so that the gap dimension is not smaller than the specified dimension	Affects seismic performance. pounding	Specification

Area for consideration	Attribute	Importance	Additional Notes
	The faces of the seismic gap should not have protrusions which will reduce its effectiveness . There should be no debris in the gap and horizontal gaps should be capped to prevent entry of debris in the future	Affects seismic performance of structure	Detailed within the design . Reiterated in the Maintenance manuals
	Where gap filling material is specified , no alternative should be allowed without agreement of the designer	Affects designed performance of the structure	LC 20 . Specification Reiterated in the Maintenance manuals
Shielding	Complimentary shielding	Can be difficult to support / fix in shutter. Can affect reinforcement cover/ placement unless detailed correctly	Carefully considered design detailing and early contractor involvement in buildability issues
	Cracks, joints	Cracking and joints can compromise shielding	Specification . Agreement of remedial actions with design team
	Concrete density	Inadequate compaction concrete materials can affect specified requirement	Specification. Workmanship supervision, testing
	Service penetrations	Can compromise shielding. Complimentary shielding may also be required	Carefully considered design detailing
Reinforcement	Placing ,tying	Reinforcement needs to be placed and tied in accordance with the requirements of the code. If the design is in accordance with the ACI codes then detailing and workmanship requirements will be in accordance with that code, or more onerous code	Specification . Code requirements

Area for consideration	Attribute	Importance	Additional Notes
	Couplers	Note specific requirements for couplers to meet ACI codes. Including fixing and inspection	Code specification. Refer to line to take.
	Cover	Critical to durability	Code specification
Reinforcement	Laps bends and links	To meet requirements of design codes	Code, Specification
	Earthing	Reinforcing bars may form part of a Faraday Cage or other earthing system. These requirements may be more onerous than the normal workmanship requirement for tying a cage	Specification and relevant Codes
	Storage	Storage of reinforcement should be carefully considered. Tolerances, bar type and reinforcement quality should be verified	Quality Assurance and testing of materials on site
	The provision of additional reinforcing bars (or oversized bars)	Can affect seismic performance of structure	Specification- change control. Supervision
	Use of galvanized or epoxy coated rebar	Galvanized rebar prohibited within ACI 349	Adequate performance of epoxy coated rebar and concrete should be demonstrated. Refer to code.
	Corrosion protection	Effects of chlorides. Deicing chemicals	Refer ACI committee 201 and 222. Pavix / Silane not now recommended
	Welding of reinforcement	Codes and Standards having varying requirements	Specification and Codes
Foundations	Site investigation / confirmation of data, ground preparation, insitu testing. Piles / rock anchor testing	Cannot inspect therefore highest standards of construction, testing and record keeping appropriate	LC 28, LC 14

Area for consideration	Attribute	Importance	Additional Notes
	Contamination	Recognition, testing, disposal	Specification, SAP's
	Unidentified services	Surveys, site location and marking	Permit to dig
Fluid retaining structures	Water bar, joint preparation, waterproof membranes	Long term durability Crack control	Good detailing, LC28
	Inspectablity, repairability,	Long term durability of structure. Control of contamination	LC28
Encast Items	Proprietary items. Halfen type channels	Dynamic response	Refer to line to take
	Post drilled fixings	Dynamic response, failure mode, rebar	Code requirements on degree of clustering . Refer to line to take
	Use of resin anchors	Failure mode. Justification	Consider conditions and Location . Refer to line to take
	Material compatibility	Selection of materials Prevention of negative reactions	Zinc reaction with alkaline materials in concrete. Galvanic reactions. Hydrogen generation and potential for hydrogen enbrittlement.
	Purpose designed encast anchorages	Material properties. Design Codes Manufacturing records, QA, SQEPs, positioning, welding	Refer to line to take
Temporary openings	Reinforcement, compaction, voids, staggered laps	Subsequent construction needs to reflect requirements of design to support safety case. Process of making good to be of appropriate standard	Involvement of designer. Specification Codes
Interface with Mechanical, Electrical and C&I architectural	Interface impacts on justification of the safety case	Use of appropriate technology for modelling of service interfaces within the design stage	
Roads , Drainage and Infrastructure	Safety issues, interaction with SR service load capacity of live service ducts	Access, emergency escapes. Control of flooding, power and emergency supplies	Involvement of the designer to ensure compliance with safety case requirements.

Area for consideration	**Attribute**	**Importance**	**Additional Notes**
Construction Cranes	Stability, ground conditions, adjacent plant	Issues associated with working adjacent to SR plant. Crane collapse	Crane design, Crane platform , Lifting Coordinator, testing inspection
Correct/ Full Design Brief	Transfer of information	Licensee has full understanding of facility usage and requirements. These need to be transferred to a workable 'brief'	Licensee will work with design house. Good communication facilitated by co-location of design team and licensee's project team. Regular Interfaces
			Optioneering record sheet; development of design
Optimisation of design through Co-ordinated discipline teams	Lack of coordination through disciplines leads to late alterations	Late changes leading to lack of clarity and rushed decisions	Co-ordinated design discipline reviews
			Appropriate modelling for areas of tight service interfaces/ penetrations
			Design complete prior to construction
			Design peer reviews
Implications of use of certain codes & Standards – More rigorous & unusual to contractor and sub contractors	Contractor works to a normal industrial standard	Unacceptable Quality Control	Contractor checked for SQEP (prior to award, following award and throughout contract) – Assurance sought that people proposed at tender are available & subsequently used. Similar SQEP issue with sub contractors and sub- sub contractors staff and QA procedures
			Rigorous Site control with Design Input as required

Area for consideration	Attribute	Importance	Additional Notes
Design specification leaves contractor scope to define alternative materials (“ or similar approved”)	Contractor specifies unsuitable materials as he is not fully aware of design requirements	Materials do not fully justify safety case	Thorough and complete checking by designer of contractors proposed materials.
			Use of material acceptance/ proposal forms. Hold point approval
Design is difficult for the contractor to construct	Contractor finds it time consuming or costly to construct	Contractor either cuts corners or proposes changes to design at late stage	Early involvement of contractor . – buildability input incorporated into design
Non-conformances	Inevitable	Can adversely affect design	Recording of non conformances (No blame Culture)
			Understanding of issue in relation to safety case and specification
			Closing out of issues including up dating of as built records
			Clear limits of authority to accept changes & non conformances on behalf of licensee by others (Design House)
Design Changes	Time / Availability		A robust design change system of recording and acceptance
		Procurement Availability	
		Contractor Proposals	
		Errors/ mistakes- Non Conformances	
		Oversights from original design	

Area for consideration	**Attribute**	**Importance**	**Additional Notes**
Records	Appropriate records developed and maintained	Timely records developed to show continuity from design through construction in order to justify operational safety case	Verification of design brief and specification are aligned (including codes, standards etc)
			Verification of appropriateness of codes/ standards to be adopted
			Certification of materials
			Verification of testing for proprietary items
			Verification that contractor selected materials are compliant with design intent
			Timely 'as constructed' drawings including appropriate referencing to design changes
Contractor methodology	Contractor methods in some circumstances need to be validated against design assumptions	Contractors methods may not align with original design assumptions	Early engagement of contractor . – buildability input incorporated into design

References

1. T/AST/039 ; Management for Safety
2. T/AST/057 ; Design Safety Assurance
3. T/AST/017 ; Structural Integrity, Civil Engineering Aspect
4. T/AST/077 ; Procurement of nuclear safety related items or services ,
5. Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations, Codes and Safety Guides Q1-Q14, Safety Series No 50-C/SG Q, IAEA, Vienna 2001
6. Nuclear Installations Act 1965 (as amended)
7. Health and Safety at Work Act 1974 (as amended)
8. The Construction (Design and Management) Regulations 2007
9. Ionising Radiation Regulations 1999
10. IAEA guidance DS349, Management System for Nuclear Facilities
11. Safety Assessment Principles for Nuclear Facilities, 2006 rev 1. HSE
12. Not Used
13. American Concrete Institute (ACI 349/06) Code requirements for Nuclear Safety Related Concrete Structures.
14. Thirteenth report of SCOSS , The standing committee on Structural Safety
15. Construction workers for whom English is not their first language (Reg 13, 15 of The management of Health and Safety at work Regulations 1999 as amended)
16. Not Used
17. T/INS/012 ; technical inspection guide LC12 DAP's and SQEP's
18. Western European Nuclear Regulators Association (WENRA) Reactor harmonisation working group, reference levels, Jan 2008.
19. CIRIA report T 30.001 Demolition, Dismantling and Decommissioning Rev 03 [Jan 09] , Designing to make management of hazards in Demolition, Dismantling and Decommissioning easier.
20. Not used
21. T/AST/049 , Technical Assessment Guide, Licensee use of Contractors and Intelligent Customer capability
22. UK CARES; url www.ukcares.com
23. American Institute of Steel Construction (ANSI/AISC 360-05) Specification for structural steel buildings.
24. American Institute of Steel Construction (ANSI/AISC 341-05) Seismic Provisions for Structural Steel Buildings.
25. American Institute of Steel Construction (ANSI/AISC N690-06 Specification for Safety Safety related structures for nuclear facilities.

26. Not Used
27. Not Used.
28. T/INS/017; Site Inspection and enforcement guidance:LC17 Quality Assurance.
29. Managing health and Safety in Construction – Construction (Design and Management) Regulations 2007 Approved Code of Practice.
30. IAEA, NS-G-3.6; Geotechnical aspects of site evaluation and foundations for nuclear power plants.
31. British Construction Steelwork Association, BCSA, www.steelconstruction.org
32. International Masonry Society, IMS, www.masonry.org.uk
33. IAEA Safety Standard GS-R-3 The Management Systems for Facilities and Activities Safety Requirements