Appendix 2 Technical Background Note

Title: The assessment of fire, blast barriers, escape routes and temporary refuges (TRs)

Introduction
This document sets out the technical background for the interventions to evaluate the robustness of arguments made by duty holders (DH) to support the ALARP position for mitigation against the effects of fires and explosions on offshore installations. In order to gain sufficient confidence in ALARP arguments, it is envisaged that a starting point for data input will be the safety case and data on hydrocarbon releases. Additional information gained through the inspection activity, e.g. post acceptance inspection topic (PAIT) issues should also be reviewed prior to undertaking these interventions.

Background/objectives
The major emphasis is to give assurance of life cycle integrity. Therefore, with regards to the management of fire and explosion risks, these interventions aim to review:

1. Whether the original assumptions regarding integrity are valid. E.g. are the load and response analyses sufficiently robust to support technical ALARP arguments in the safety cases?
2. Physical changes to the installation that may impact on the risk and require additional risk reduction measures to be reviewed/adopted.
3. Deterioration in the plant/structure condition, in particular the weathering of passive fire protection (PFP) systems and failures in the pressurised containment of the temporary refuge (TR), and its effect on the continuing suitability of the installation.
4. The management system that captures the above is suitably robust and enables critical changes to be incorporated into the DH review and instructions given to key personnel.

The basis of these interventions will be to focus on key installations that carry a higher than average fire/explosion risk. Data from hydrocarbon releases for attended installations will be used as a guide.

Issues addressed

1. The suitability of mitigation barriers to prevent escalation, protect the TR.
2. The suitability of structures to allow escape to the TR and embarkation points and evacuation from the installation.
3. In service performance testing, inspection and assessment of fire and explosion safety critical elements.
4. The DH management system to control the above.

**Detailed activity description**

**The suitability of mitigation barriers to prevent escalation, protect the TR**

This activity requires the inspector to ensure that barriers between different areas on the platform are suitable to prevent unwarranted escalation between different areas, and that sufficient time is provided such that the barriers do not impair the TR, for a defined duration. Blast resistance and fire load endurance are the key technical issues to be addressed.

Generally, the fire barrier performances have been determined according to SOLAS ship requirements with regards to a basic classification, and EN ISO 13702 which has given more detailed requirements for offshore installations.

**Fire hazard scenario review**

The inspector duties are as follows:

Check that all credible fire scenarios have been included in the major accident hazard (MAH) register, relevant to the structural safety critical elements (SCE). This should include:

- Oil pool fires in process, drilling modules and the sea (riser leaks etc).
- Riser jet fires.
- Process jet fires.
- Oil mist fires.
- Condensate fires.
- Accommodation fires.

**Fire barrier suitability review**

The inspector should confirm that critical barriers are suitable to resist, either all credible fire scenarios, or those risk based fire scenarios which allow risks to personnel to remain ALARP. This should entail as a minimum checking the DH’s installation’s barriers comply with ISO 13702, which is a minimum good practice requirement.

Within the DH’s fire risk assessment, the barriers protecting the TR, can withstand the fire exposure and duration limits for the scenario determined. With regards to the barrier provision, the following standard classifications are relevant:
<table>
<thead>
<tr>
<th>Barrier Rating</th>
<th>Stability and Integrity Duration (Minutes)</th>
<th>Insulation Duration (Minutes)</th>
<th>Jet Fire Stability and Integrity Duration</th>
<th>Jet Fire Insulation Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>H120</td>
<td>120</td>
<td>120</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>H60</td>
<td>120</td>
<td>60</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>H0</td>
<td>120</td>
<td>Not suitable</td>
<td>60</td>
<td>Not suitable</td>
</tr>
<tr>
<td>A60</td>
<td>60</td>
<td>60</td>
<td>Not suitable</td>
<td>Not suitable</td>
</tr>
<tr>
<td>A30</td>
<td>60</td>
<td>30</td>
<td>Not suitable</td>
<td>Not suitable</td>
</tr>
<tr>
<td>A15</td>
<td>60</td>
<td>15</td>
<td>Not suitable</td>
<td>Not suitable</td>
</tr>
<tr>
<td>A0</td>
<td>60</td>
<td>0</td>
<td>Not suitable</td>
<td>Not suitable</td>
</tr>
<tr>
<td>B15</td>
<td>30</td>
<td>15</td>
<td>Not suitable</td>
<td>Not suitable</td>
</tr>
<tr>
<td>B0</td>
<td>30</td>
<td>Not Suitable</td>
<td>Not suitable</td>
<td>Not suitable</td>
</tr>
</tbody>
</table>

Table 1 Barrier Ratings Exposed to Hydrocarbon Pool/Jet Fires and Cellulosic

**Blast barrier suitability review**

The blast barrier suitability is more difficult to assess. However, as the majority of the installations being reviewed are complex layouts, high inventory risk, and permanently attended it is recommended that the inspector conduct a review in line with the latest Oil and Gas UK document. The following details the issues that should be included in the DH assessment:

- A complete set of explosion scenario investigations.
- CFD simulations of gas dispersion, zonal models, the Shell DICE model or the workbook approach if it can be justified.
- Determination of equivalent stoichiometric cloud size.
- A combination of CFD and phenomenological explosion simulation with generation of exceedance curves representing frequency of overpressure exceedance.
- Determination and assessment of the structure and SCEs against the SLB and DLB design explosion loads including blast wind dynamic pressures.
- Dynamic possibly non-linear modelling of the installation and systems response.
- Explicit consideration of escalation and interaction between fire and explosion scenarios including the collapse of tall structures and the external explosion effects on adjacent structures, in particular the TR.
- Consideration of strong shock and missile generation by the explosion.

The suitability of structures to allow escape to the TR and embarkation points and evacuation from the installation

The inspector should check (in no particular order):

Criticality of structures

The DH should have a logical framework for identifying criticality of structures with regards to the blast, and duration and type of fire that such structures are needed to resist. For example, this could include:

- Primary structural joints/members of the MSF, TR support structure to withstand a targeted jet fire.
- Escape routes across bridges, around/underneath process and drilling areas are suitably protected from major fires to enable escape to the TR/safe areas.
- Support steelwork to critical pipework/valves, such as ESDV support clamps’ steelwork, hangar steelwork for vent lines and deluge pipework. Note that often the support steelwork is itself attached to decks/walls/roofs that could suffer large blast displacements. Local analysis of deflection and loads on vent, deluge lines etc is a crucial part of the DH ALARP demonstration.
- Base supports for plant/structures where high drag loads due to blast funnelling etc could be a dominant load case, or fire scenarios could result in failure before the assumed evacuation time.
- Evacuation walkways to TEMPSC, helideck, spider deck areas are suitable for the assessed fire/blast loads. In some cases DHs are
providing GRP lightweight grating and it’s suitability as a robust evacuation route should be demonstrated by the DH.

- Helideck structures.

**Endurance of structures in a fire**

The DH should ensure that all primary and secondary structural steelwork (or other metals) can withstand the various fire scenarios, either with, or without, additional passive protection. Within this check, the DH often quotes standard temperatures to which critical members can be exposed (see below). This should form the basis of the inspector review and additional risk based remedial measures should be continuously reviewed by the DH (refer to Table 2 below).

<table>
<thead>
<tr>
<th>Structural Component</th>
<th>Typical Maximum Steel Surface Temperature and Duration</th>
<th>Justification for Exposure Temperature &amp; Duration</th>
<th>Main ALARP Measures</th>
<th>Uncertainties to be Explored with DH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supports to TR, accommodation areas and steel helideck structure.</td>
<td>400°C for 60 minutes. Note that limiting temperature for aluminium helidecks is 200°C</td>
<td>Material yield strength unaffected within escape period and/or fire duration.</td>
<td>PFP, separation by distance, redundancy in load paths (lost member analysis), blowdown, deluge</td>
<td>Thermal analysis (screening) accuracy, material creep as stiffness reduced by 30% at 400°C, damage to PFP, PFP condition and performance</td>
</tr>
<tr>
<td>Other primary and secondary steelwork in say process, drilling areas.</td>
<td>550°C, or higher. No specific time limit.</td>
<td>At 550°C escalation by material yielding is likely. Decision to protect is an asset and PLL risk based decision</td>
<td>PFP, redundancy in load paths, blowdown, deluge.</td>
<td>Escalation paths, thermal analysis (screening) accuracy, material creep, damage to PFP where used</td>
</tr>
<tr>
<td>Structural supports for the ESDVs and underdeck riser pipework inboard of the ESDV</td>
<td>200°C for 60 minutes.</td>
<td>Catastrophic loss of installation should riser, ESDV fail. ALARP solution.</td>
<td>PFP, support redundancy, riser location relative to TR.</td>
<td>Damage to PFP, enclosures due to blast followed by a fire.</td>
</tr>
<tr>
<td>Pipe support steelwork, failure of which could escalate to TR</td>
<td>350°C for 60 minutes.</td>
<td>Localised PFP increase justified to limit escalation over</td>
<td>PFP, plus coatback protection of secondary</td>
<td>Coatback assessment, pipework expansion and</td>
</tr>
</tbody>
</table>
Table 2 Endurance of Structural SCEs in Fire

**Note:** also that the DH should be able to demonstrate that where significant strains are likely to PFP protected steelwork due to a blast load, then the integrity of the PFP provided is ensured (limited test data is available for weathered PFP systems to support such claims).

With regards to the barrier rating inspectors should question the DH on:

1. Only H60, H120, or equivalent jet fire ratings J30, J60, can be adopted to resist jet fires. Specific thermal analysis, testing of other barriers should be requested to confirm their acceptability.

2. The ratings are based on limited fire testing on representative barriers.

3. For large strains predicted on cementitious PFP protected steelwork (e.g. Mandolite), the bond could be broken – the situation is made worse for weathered PFP systems where little test data exists to support integrity assessment.

**In service performance testing, inspection and assessment of fire and explosion safety critical elements**

The primary SCE to be reviewed offshore is the TR. The inspector should:

**Review the smoke/gas ingress functionality performance standard for the TR**

This is executed via the DH shutting down the HVAC system and monitoring the flow rate of air into the TR via a specific fire damper inlet at a point when the required positive pressure is 50 Pa. The rate of flow necessary to maintain this pressure per hour divided by the net TR volume gives an acceptance standard for the TR to maintain a suitable positive pressure for 60 minutes – usually this ratio is about 0.35 which means that it would take about 3 hours for the positive pressure to dissipate in an emergency situation. The inspector should:

a) Request copies of the TR integrity test. Often part of the ICP verification tests.

b) Review causes for failure to meet the test e.g. poor fitting door seals, gaps in penetrations through TR.

c) Determine the acceptability of the DH remedial action plans, such as door/seal replacement, or further analysis to ensure 60-minute TR integrity is assured in the degraded state.
**Review the fabric condition of the PFP and TR insulation**

The DH should hold a detailed survey report on the PFP. On cementitious PFP, wetting, spalling and sub-surface corrosion are areas for particular attention. Underdeck PFP is also prone to detachment. Any weakness in the PFP should be recorded by the DH and remedial actions listed. More modern TRs of stainless steel may not have PFP externally and rely on internal thermal barriers. The inspector should ensure that the DH has met their performance standard for the TR fire protection and note/follow-up on remedial measures. A very short timescale for repair, within 3-6 months, would be reasonable for re-instatement to the design condition, unless the DH has executed site-specific fire hazard studies to show that the existing degraded state is acceptable and risks are ALARP.

**Review weaknesses in the structural elements of the TR to resist blast and any remedial measures proposed, or rejected by the DH**

Typical elements on accommodation modules which have low explosion resistance are:

a) Doors into TRs have assessed resistances of as low as 0.1-0.2 bar. Door replacement may be one option, but more detailed external explosion analyses may indicate a rapid fall off of overpressure for extreme events.
b) Sheeting rails on older LQ cladding systems have poor resistance to buckling and capacities of 0.1-0.2 bar have been observed. Again the DH should demonstrate that such strengthening is not reasonably practicable.

c) Poorly designed penetrations, windows, particularly when located at high stress locations which cause premature fracture, yielding of stiffened cross sections. Procedures for the construction, design and siting of penetrations through TR boundaries should be reviewed.

**Review the duty holders management system to control the risk of structural failure, escalation due to fire and explosion**

This aspect of the inspection should reflect some of the KP3 templates already produced for maintenance management. Appendix 1 provides a suitably amended question set relevant to the fire and explosion risk control, which should be used by structural inspectors.

**References**

The key reference documents used to produce this technical note are:

1. Fire and Explosion Guidance – Part 1: Avoidance and Mitigation of Explosions, Oil and Gas UK/HSE, 2007
3. ISO 13702:1999 Control and Mitigation of Fire and Explosions on Offshore Production Installations – Requirements and Guidelines
5. OSD Fire Strategy, PS/01/15, HSL 2002 (Internal Use Only)