NOPSEMA
Australia's offshore energy regulator

INFORMATION PAPER

Management of hot surfaces (DRAFT)

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1. Purpose

This paper provides information on the control of hot surfaces to ensure that the risk of high temperature ignition of flammable hydrocarbon gases, vapours or liquids is managed to as low as reasonably practicable. It discusses general principles around control of the risk of ignition as applied in Commonwealth waters and designated coastal waters where powers have been conferred (e.g. Victoria).

Although it refers to Hazard Area Classification (HAC) and electrical codes, it only focusses on non-electrical equipment in open process areas. It does not aim to provide specific guidance on ignition risks associated with hot surfaces inside equipment or enclosures (e.g. gas turbine enclosures or junction boxes).

2. Background

Auto-ignition temperature (AIT) refers to the temperature at which the ignition of flammable gases, vapours or liquids can take place without the presence of a naked flame or spark. To reduce the risk of auto-ignition of hydrocarbons, and the subsequent risk of a Major Accident Event (MAE) due to hydrocarbon fire and/or explosion, it is necessary to control and manage the presence of hot surfaces in process areas where hydrocarbons may be present.

Legislative requirement

Schedule 3 to the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* requires, in Clause 9(2)(c), that the operator of a facility must *'take all reasonable practicable steps to ensure that any plant, equipment, materials and substances at the facility are safe and without risk to health'*.

NOPSEMA has received multiple 'dangerous occurrence' notifications from operators, resulting from elevated surface temperatures associated with turbines, steam systems and boilers. Each reported incident has been unique due to the specific type, design, and layout of equipment, as well as the design standards applied and the types of hydrocarbons at the facility.

This information paper is intended to raise awareness of the risk and highlight appropriate approaches to managing these risks. It presents observations and NOPSEMA expectations with regard to general risk management approaches, based on industry standards and relevant good industry practice to ensure that plant equipment at a facility is safe and without risk to health.

3. Area classification

3.1. Defined releases and hazardous area classification

In order to facilitate the selection and installation of equipment to allow safe operation, Hazardous Area Classification (HAC) methodology (typically managed by the discipline of electrical engineering) has been developed as a method of assessing and classifying the environment where explosive gas atmospheres may occur. HAC considers frequent, small releases from, for example, pipe flanges or valve stems, but not catastrophic failures associated with for example a welded pipe or pressure vessel failure. The classification takes into account the likelihood of a flammable environment occurring (i.e. zone), the ignition characteristics of the gas or vapour such as ignition energy (i.e. gas group) and ignition temperature (i.e. Auto Ignition Temperature (AIT) or 'T' class). [Ref 3]

In summary, if a flammable atmosphere is likely under normal or expected operation, the area is classified as hazardous. Table 1 below is an illustration of the different hazardous zones [Ref 7]:

Zone Classification	Grade of Release	Duration
0	Continuous	> 1000 hrs/per annum
1	Primary	10 - 1000 hrs/per annum
2	Secondary	< 10 hrs/per annum

Table 1: Relationship of grade of release and duration of flammable atmosphere to zone in an open area

HAC standards such as EI 15 [Ref 7], AS/NZS 60079.10 [Ref 4] and IEC 60079.10 are frequently used to specify the ignition controls of both electrical and non-electrical equipment.

Standards typically used for controlling the risk of potentially flammable atmospheres from electrical equipment also contain guidance on managing the risk of ignition from hot surfaces. It is recognised (Europe Designs [Ref 8] & EI 1 [Ref 6]) that HAC is also applicable to non-electrical equipment: *"For installations where there is the potential for the existence of flammable atmospheres, electrical and certain non-electrical apparatus may present an* ignition *risk and, where possible, should be located in a non-hazardous area. However, where this apparatus needs to be located in a hazardous area, explosion-protected apparatus which will not cause an ignition should be used."* [Ref 6]

It has been common industry practice to use the T-class temperature derived from HAC codes for the specification of non-electrical equipment maximum surface temperatures within HAC zoned areas.

3.2. Large or catastrophic releases in process areas not classified as hazardous

HAC classification does not address potentially catastrophic failures leading to large release of flammable hydrocarbon, which could disperse into adjacent non-hazardous classified areas.

Many offshore Australian field compositions are wet gas condensate type where catastrophic failures may result in flammable hydrocarbon gas dispersion, with relatively low AIT, that extend beyond the classified hazardous area (zones).

For a large (or catastrophic) release, ignition controls are required to minimise the potential of explosion. By design, ignition controls are typically achieved by:

- Emergency shutdown – removing the ignition source upon detection of a release, e.g. isolation / shutdown of all non-ex rated equipment (for example, on gas detection, the ESD system may shut down gas turbines); and/or
- Explosion protection – ensuring that sources of ignition that are required to remain energised (e.g. emergency lighting, gas detection and ESD systems) are Ex rated or otherwise appropriately protected; and/or
- Protected enclosed spaces – locating equipment within enclosed spaces (for example, an electro/hydraulic power unit), provided with gas detection on the HVAC inlets which shutdown the HVAC and dampers on gas detection; and/or
- Separation – positioning of equipment in areas beyond the reach of large releases (e.g. the diesel fire water pumps will be located away from the process area within a protected enclosure).

This requirement is determined using methods such as risk assessment, dispersion modelling, hazard studies and layers of protection analysis (LOPA). Dispersion modelling of potential large (or catastrophic) releases provide an estimate of the dispersion limits of the released hydrocarbon fluid (gas, vapour of liquid). The model identifies the composition of the fluid and, as a consequence, the AIT.

4. Determination of Auto-Ignition Temperature (AIT)

Auto-ignition temperature (AIT) can be defined as: *"The temperature at which a substance will begin to burn without application of any source of ignition"*. [Ref 6]

AS 60079-20-1 [Ref 12] provides a list of AIT temperatures for various hydrocarbon materials (e.g. methane and ethane) and some common hydrocarbon mixtures (e.g. kerosene). These results are widely used by industry and referred to by many standards.

For mixtures, the most conservative AIT (i.e. the ignition temperature of the individual component with the lowest AIT) should be specified, or the AIT determined by laboratory tests (IP 15 [Ref 7], IEC 60079 [Ref 4], EN 1463-1 [Ref 8], IP 1 [Ref 6]). Standards which use an alternative approach to this include:

- ISO 21789 - Gas turbine applications — Safety [Ref 11]:

  "*For mixtures, unless test data are available, the AIT of the component having the lowest AIT and present at a concentration of over 3 % (by volume) shall be used."*

- API RP 14C - Analysis, Design, Installation, and Testing of Safety Systems for Offshore Production Facilities: [Ref 1]:

  "Any surface including portable equipment with a temperature in excess of 204°C should be protected from exposure to hydrocarbon liquids due to spillage or leakage. Surfaces including portable equipment with a temperature in excess of 385°C *should be protected from exposure to accumulations of combustible gases and vapours*."

In hazardous areas, the composition of a potential flammable gas and vapour is defined by the contents of the leak source as defined by the process model. In non-hazardous areas, the determination of AIT becomes more complex. Normally, all of the potential hydrocarbon containing releases from process systems that could (during a large or catastrophic release) cause ignition in an area, and the AIT of each, have to be determined, and includes consideration of additional factors, for example climatic conditions.

Note: The expected 'real' condition of a gas cloud has to be established/modelled when determining gas composition of a process stream. For example, to simplify release compositions through the assumption of an adiabatic flash, may not be a true representation of the composition of an actual release.

5. Defining operational temperature limits in non-HAC areas affected by large releases

Maximum external surface temperatures of equipment in process and open deck areas need to be specified, controlled and monitored to reduce the risk of fire or explosion (caused by flammable hydrocarbons reaching hot surfaces) to a level that is ALARP. For design, as discussed above, it is common to specify the 'T' temperature class as the maximum surface temperature of equipment. This is generally a robust approach to ensure ALARP conditions exists.

However, it has been found (during commissioning and subsequent operational monitoring) that measured surface temperatures may exceed the area 'T' class or specified equipment design temperature. Hotter-than-expected surface temperatures due to degradation of insulation material is a common example.

It is standard practice to describe a hot surface assurance inspection program in a performance standard. The majority of reported unexpected high surface temperatures have been discovered during assurance activities, using handheld equipment. The risk has to be managed immediately following discovery and the appropriate course of action determined.

For non-hazardous and HAC Zone 2 areas, it is recognised that if the maximum operating surface temperature is maintained below AIT, it is unlikely that ignition will occur. Applying a T class provides some additional safety margin in HAC zones, as T Class temperature is less than the AIT.

The maximum operating surface temperature is defined as "the maximum external surface temperature that can be reached during the most adverse operating conditions". Temperature measurements should be accurate, and corrected for ambient and operating conditions to be a true reflection of the maximum operating surface temperature.

API RP 2216 [Ref 2] concludes that: *"Ignition of hydrocarbons by a hot surface should not be assumed unless the surface temperature is approximately 182°C above the accepted minimum ignition temperature of the hydrocarbon involved"*. The Energy Institute [Ref. 7] notes with regards to API 2216 that: *"This is a general rule of thumb. It should not be regarded as a definite limit"*.

6. Interpretation of elevated surface temperature results

At a facility, the known potential "hot surfaces" are controlled through assurance activities as described in performance standards and the required actions with regards to reporting and mitigation are understood.

Incidents of "hot surface exceeding assurance limits", mentioned above, have been unique and required careful consideration by subject specialists, depending on the applicable codes and standards and the conditions specific to each facility. It is complex to provide informative guidance applicable to all facilities, each with unique field composition, process layout and conditions, and designed and operated using different codes and standards.

	AREA CLASSIFICATION		
	Hazardous (HAC) AIT & T-Class determined during design phase using HAC		**Non HAC, within dispersion model "risk zone"** AIT determined through dispersion and risk assessment process
	Zone 0&1	**Zone 2**	
Above AIT + 182°C	Immediate threat exists	Immediate threat may exist	Immediate threat may exist
AIT to AIT + 182°C	Immediate threat may exists	Consider Immediate Intervention	Exceeds most codes – ALARP justification required, normally ORA* until < AIT
Design / T-Class Temperature to AIT	Exceeds Design – ALARP justification required	ALARP justification may be required, dependent on Design	Acceptable
Below Design / T-Class Temperature	Acceptable	Acceptable	Acceptable

* Further Guidance is available in NOPSEMA Guidance Note: Operational Risk Assessment N-04300-GN1818

Figure 1: Risk of ignition due to maximum operating surface temperature

7. Conclusion

- The risk of ignition of hydrocarbons by hot surfaces must be minimised to ALARP during the design phase of a facility for all (hazardous or non-hazardous) areas.
- Specific maximum operating surface temperature limits for relevant areas are determined during design; and normally specified to be below the T-class or lowest AIT of the hydrocarbons that introduces the risk to the relevant area.
- Performance standards must define assurance activities to manage the risk of ignition of hydrocarbon by potential hot surfaces to a level that is ALARP.
- When a potential hazardous 'hot surface' related exceedance or non-compliance with a safety case commitment, performance standard or an industry standard is discovered, an operator must take steps to mitigate or reduce the risk of ignition to as low as reasonably practicable and notify NOPSEMA of the dangerous occurrence. The steps to mitigate can include (but are not necessarily limited to) a combination of the following:
  - shutting down equipment, or adjusting of process parameters to reduce temperatures
  - delay or suspension of high risk activities

- formal risk assessment
- increased frequency of surface temperature monitoring
- additional dispersion modelling
- re-engineering of equipment with elevated surface temperature
- safety case revision
- re-evaluation of Hazardous Area Classification
- changes to equipment layout.

8. References

API Recommended Practice 14C, Eighth Edition, February 2017, Analysis, Design, Installation and Testing of Safety Systems for Offshore Production Facilities.

API Recommended Practice 2216, 3rd Ed, December 2003, Reaffirmed October 2015 – Ignition Risk of Hydrocarbon Liquids and Vapours by Hot Surfaces in the Open Air.

Australian/New Zealand Standard AS 60079-10, 2009, Explosive atmospheres Part 10.1: Classification of areas—Explosive gas atmospheres.

Australian/New Zealand Standard AS 60079-0, 2019, Explosive atmospheres Part 0: Equipment—General requirements (IEC 60079-0:2017 electrical equipment).

Australian/New Zealand Standard 60079-14, 2017, Explosive atmospheres Part 14: Design selection, erection and initial inspection, electrical equipment.

Energy Institute Model Code of Safe Practice, Part 15, 4th Edition, June 2015, Area Classification for Installation handling Flammable Fluids.

Energy Institute Model Code of Safe Practice, Part 1, 9th Edition, July 2019, The Selection, Installation, Inspection of Electrical and non-Electrical Apparatus in Hazardous Areas.

European Standard - EN 13463-1, November 2001 - Non-electrical equipment for potentially explosive atmospheres, Part 1: Basic method and requirements.

European Standard - EN 1127-1, July 2011 - Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology.

International Standard - ISO 13702, August 2015, Petroleum & Natural Gas industries – Control & Mitigation of fires and explosion on offshore production installations – Requirements and Guidelines.

International Standard - ISO 21789: 1st Edition, February 2001 - Gas turbine Applications – Safety.

Australian/New Zealand Standard AS 60079.20.1: 2012, Explosive atmospheres - Material characteristics for gas and vapour classification – Test methods and data.