Improving front line and managerial loss of containment incident safety decision making and dynamic risk assessment through new guidance and a training toolkit.

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The Energy Institute (EI) commissioned a project to prepare guidance and a toolkit for training and managing the initial response to loss of containment incidents, principally in the oil and gas industries, but applicable to all process industries with major accident hazards potential.

The objective of the project was to improve loss of containment immediate incident response capability and management, by training teams to make better safety decisions during dynamic risk assessments. The focus is on front line operations personnel and their immediate managers. The guidance and toolkit provide a systematic approach to designing the response to loss of containment and also the training requirements to maintain readiness for assessing situations, then identifying and implementing the correct responses, both on a personal and team basis.

Past incidents were reviewed to identify the issues raised and lessons learned, responses that resulted in casualties and near misses or incidents that were successfully managed without injuries. The review found many common themes, including problems with:

- Isolation of leaking equipment
- Organisation, Competence, Training for emergency response
- Management of Change in equipment or organisation

Although some incidents reviewed occurred over 20 years ago, the same themes recur and many more incidents could be referenced highlighting the same issues.

The current arrangements, training, standards and guidance for responding to loss of containment incidents for both upstream and downstream oil and gas operations were also reviewed and a survey of operating companies carried out.

The major concerns about the current arrangements were:

- Operators or front line responders' tendency to intervene immediately at the location of the loss of containment exposing themselves to the risk from an event escalation; and,
- The occasions where keeping the plant running appeared to be a higher priority than operator safety, often in contravention of companies' high level policies, so no action was taken to isolate the affected equipment or shutdown the plant. (In some cases, isolation was not possible or was seriously delayed).

Keywords: Emergency response, loss of containment, leak, emergency planning, emergency training, safety awareness, hazard potential.

Introduction

Responses to loss of containment incidents do not appear to be consistent across the process industries. In particular, there are wide variations across the oil and gas sector. The Chevron, Richmond Refinery 2012 incident (U.S. Chemical Safety and Hazard Investigation Board 2014) was one of the incidents that prompted the need for this project. This incident highlighted concerns that some operations teams do not realise the potential severity of a loss of containment event and send personnel to investigate before ensuring it is safe to do so. Operations teams may be motivated by the need to make a heroic response or to avoid unnecessary shutdowns, which is their 'normal' operational mind-set. However, failure to achieve prompt isolation or shutdowns (or some other safe state to achieve safe assessment and repair) may, if the situation escalates, lead to casualties amongst the investigators or responders and to severe damage to plants and prolonged shutdowns. In many cases of serious incidents there have been fatalities and the site has never reopened.

The work concentrated on the first 30 to 60 minutes of a loss of containment incident before the arrival of on-call emergency team members or any external emergency assistance. The guidance and toolkit is to be published by the Energy Institute (EI 2017).

Review of past incidents

Response in past loss of containment incidents – major accident reports

The review examined the reports of accidents in the U.S. Chemical Safety and Hazard Investigation Board archive, UK Health & Safety Executive major accident investigation reports, and the European Union database of Major Accidents Reports (eMARS).

The incidents listed in Table 1 were reviewed. The issues raised and lessons learned (some positive) were summarised as:

Isolation: A suitable means of 'remote' or 'automated' isolation should be provided in the design of hazardous plant and when a loss of containment occurs isolation should be achieved before any intervention is attempted. The issues identified and lessons drawn from particular accidents include:

- Isolate where possible before any aggressive action; if isolation not possible then shut-down (Chevron, Richmond Refinery).
- The deployment of the Response Team before isolations were in place (ConocoPhillips, Humber Refinery).
- There was no means of isolating the flow from gas pipelines connected to other platforms at Piper Alpha and no pre-arranged means of requesting the other platforms to shut-off flow (Occidental, Piper Alpha).
- Following the disaster there was an assessment of all pipelines connected to manned platforms to determine the need for sub-sea isolation valves (SSIVs) close to the platform to shut-off flow automatically in the event of an emergency (Occidental, Piper Alpha).
- A more thorough assessment of the hazards and identification of potential accident scenarios should have led to a recognition of a need for remotely operated isolation of the significant inventories of hazardous materials and a more structured arrangement for identifying, inspecting and maintaining critical components (Associated Octel, Ellesmere Port).
- As well as lack of remote isolation of the hazardous inventories there were also inadequate procedures for isolating electrical equipment some of which remained live until the following day (Associated Octel, Ellesmere Port).

Numbers of People at Risk: The area in the vicinity of a leak should be evacuated and intervention by a minimum number of investigators only authorised after proper assessment. Incident managers must know the location of all personnel. Accident reports from several accidents have highlighted this:

- Avoid large groups, or anyone approaching the area that might be hazardous (Chevron, Richmond).
- Too many operators in the vicinity during hazardous start-up and leak follow-up (Tesoro, Anacortes Refinery).
- Avoid human presence during hazardous operations (Tesoro, Anacortes Refinery).
- A large group also congregated near one of the locations of liquid accumulation (Texaco, Pembroke Refinery)
- The deployment of the Response Team before isolations were in place (ConocoPhillips, Humber Refinery).
- The lack of accurate roll call information to identify missing persons which delayed the rescue of an employee from the office building (Hickson & Welch, Castleford).

Competence: Frontline staff need to be selected, trained and competent in the immediate response to loss of containment. Comments arising on this from accidents include:

- Requirements for the selection, training and competence of Control Room Operators (CROs) and Offshore Installation Managers (OIMs) should be specified (Occidental, Piper Alpha).
- Generic type training should not be used for critical task requirements but where it has been used, requires supplementing to cover the actual 'live' operational plant or process (Centrica, Rough).

Situational Awareness / Weak Signals / Acceptance of Risk: Operations teams (Field Operators, CROs and their team leaders) should be aware of the potential consequences of a loss of containment and not rely on their general experience that most leaks are small and do not usually escalate to a major incident. The potential for larger leaks is increased when equipment is degraded so the operations team should be particularly aware of any reports of degradation of containment (e.g. corrosion / erosion) or other safety critical systems. Particular recommendations from incidents include:

- A drip may indicate a significant problem, ensure "weak" signals are communicated to all staff involved, including front line. (There should be a process in place to determine when a leak – seep, weep or drip – may be significant in terms of leading to a hazardous event) (Chevron, Richmond).
- Do not accept occurrence of leaks as normal (hydrogen release during start-ups considered normal) (Tesoro, Anacortes Refinery).
- Consider information from all sources to understand plant status, allow challenge of model of how the process responds and avoid persistence (Texaco, Pembroke Refinery).
- Lack of a valid interpretation of the incident at the outset (ConocoPhillips, Humber Refinery).
- Fire water for cooling deluges should be available when hydrocarbon processing is ongoing (Occidental, Piper Alpha).
- Minimise risk during interventions – if determined safe to approach always use at least two gas detectors when investigating hydrocarbon leaks – one to monitor leak and one to check for breathable atmosphere (oxygen content or H_2S in the case of sour gas or liquids) (Shell, Brent Bravo).

- The emergency plan and training concentrated on toxic releases (the major off-site hazard) and did not give enough consideration to the possibility of fires and explosions for which the emergency responders needed to be prepared, particularly in terms of their training. (An additional problem was the erosive property of the reactor fluid which rendered masks opaque) (Associated Octel, Ellesmere Port).
- Balancing safety vs. environmental protection led to a difficult decision over which well control mitigation strategy to select; the options were early control of the well via human intervention on the platform/rig under deluge protection, or waiting for a relief well to be drilled. In this case, safety concerns prevailed over environmental protection (PTTEP, Montara)

Organisation & Management for Emergency Response: In preparation for an emergency there should be clear delegation of authority. Recommendations have included:

- Provide clear designation of the person in charge under both operating and emergency conditions (BP, Macondo Field / Transocean, Deepwater Horizon Rig).
- There was a delay of over an hour in the arrival of the Duty Manager at site to provide technical support to the shift team. One other manager, acting as his back-up, was prevented from reaching the site by the police cordon (Associated Octel, Ellesmere Port).
- Incident manager should supervise not take on other roles (e.g. investigation, search & rescue), all roles should be covered by the on-shift team (VCM, Australia and Texaco, Pembroke Refinery).

Development of Response Plans: Both generic plans and those for response to particular types of emergency need to be developed in sufficient detail. Issues raised after incidents included:

- Communications routing between the On-Site Incident Controller through a third party (Onshore Control Room Operator), for activation of the Support Response Management Team led to delays as no 'confirmation hand-shake' protocol was established and the request had to be repeated (Centrica, Rough).
- Information transfer is critical for many reasons. Certain improvements were made to the overall Emergency Response Management process even though it was deemed adequate (Centrica, Rough).
- The initial incident was raised as a 'general type incident' and didn't initiate the urgency awareness (Centrica, Rough).
- The routing of the initial response was duplicated to a number of different persons through different routes and could have caused confusion and possibly missed critical responses (Centrica, Rough).
- Consider other major hazards as well as the dominant one(s) (Associated Octel, Ellesmere Port).

Training and Competence Assurance to follow the plan: The frontline operations team need to be aware of and follow the pre-planned safe actions and not improvise; safe behaviours form part of a good safety culture. Lessons learned from behaviour during incidents included:

- Avoid impromptu actions that may exacerbate the situation (Chevron, Richmond)
- Avoid impromptu actions that may exacerbate the situation (Texaco Pembroke Refinery)
- The deployment of the Response Team before isolations were in place (ConocoPhillips, Humber Refinery)
- Define the type, frequency, extent, randomness and evaluation criteria for all emergency contingency drills. (BP, Macondo Field / Transocean Deepwater Horizon Rig)
- Require the crew to practice launching liferafts during evacuation drills (BP, Macondo Field / Transocean Deepwater Horizon Rig)
- Training needs to be ongoing particularly for the front line crews and supervisors. (VCM Australia)
- The Lifeboat Coxswain in charge at Lifeboat Muster Station took accountability to launch the lifeboat and make escape to sea on his own assessment of the impending escalating situation rather than wait for instruction. (Centrica, Rough)
- Prompt evacuation in the face of an uncontrolled release potentially saved many lives – if earlier ignition had occurred then this may not have been achieved. (PTTEP, Montara)

Protection of Occupied Areas: In order to respond to a loss of containment control functions need to be in a safe area and escape routes need to be secure – this is properly part of the design process but any shortfalls need to be taken into account in emergency response plans not least for the protection of operators:

- The Control Room was probably put out of action in the initial explosion, it was not possible to activate all the emergency systems from another location, even if they had been available (Occidental, Piper Alpha).
- Normally occupied buildings (temporary or permanent) may not be safe locations in a major accident (Hickson & Welch, Castleford and BP, Texas City).

- The EER (evacuation routes, survival equipment in place, lifeboats availability) arrangements worked effectively, thus minimising any escalation and reducing the possibility of any fatalities (Centrica, Rough).

Design, Maintenance and Repair Measures: There are lessons in these areas from the major incidents studied which fall outside the remit of the initial emergency response. Designers and managers should ensure that the frontline operations team are provided with the equipment and control measures to respond to loss of containment incidents and prevent escalation without endangering themselves.

Table 1 Significant accidents with lessons for initial response to loss of containment

Incident Name	**Year**	**Reference**
Associated Octel, Ellesmere Port	1994	HSE 1996
BP, Macondo Field / Transocean Deepwater Horizon Rig	2010	BP 2010 United States Coast Guard 2011 National Commission 2011
BP, Texas City	2005	U.S. Chemical Safety and Hazard Investigation Board 2007
Centrica, Rough	2006	Centrica Storage Ltd 2006 HSE 2006.
Chevron, Richmond	2012	U.S. Chemical Safety and Hazard Investigation Board 2014
ConocoPhillips, Humber Refinery	2001	HSE 2005
Hickson & Welch, Castleford	1992	HSE 1994
Occidental Piper Alpha	1988	Cullen 1990
PTTEP, Montara	2009	Commonwealth of Australia 2010
Shell, Brent Bravo	2003	Private Communication
Tesoro Anacortes Refinery	2010	U.S. Chemical Safety and Hazard Investigation Board, 2014
Texaco, Pembroke Refinery	1994	HSE 1997
VCM, Australia	1999	Cann 2014

Response in past loss of containment incidents – eMARS[1]

The eMARS database contains reports on all European Major Accidents reported under the Seveso Directives. This was interrogated for all loss of containment accidents reported as occurring in oil, gas or petrochemical facilities and involving some references to emergency response. A total of 79 records were identified.

The lessons learned (usually company or regulator recommended improvements) included (numbers of incidents in brackets):

- More rapid isolation or shut-down, (18), achieved mainly through installation of automatic trips linked to fire or gas detection and levels, but also through location of ESD (emergency shut down) push buttons, installation of motorised, remotely operated valves and better decision making processes;
- Better means of detecting the leak (loss of containment) (10), resulting from leaks under insulation, leaks through the base of storage tanks, leaks in machinery (such as pumps or compressors), leaks into drains or other non-hazardous streams and significant gas leaks that were not recognised (no pressure drop) or where a pressure drop met with a response to maintain pressure, thus increasing the leak size; some recommendations linked fire detection with automatic shut down (included in the recommendation above);
- Planning and preparing response (5), in 3 cases PPE was not used or it was incomplete/inadequate for the purpose and this was linked with heroic, perhaps unauthorised, action to mitigate release consequences (for example to close manual isolation valves or open deluge valves, see first bullet above);

[1] European electronic major accident reporting system which contains reports of chemical accidents and near misses provided to the Major Accident and Hazards Bureau (MAHB) of the European Commission's Joint Research Centre from EU, OECD and UNECE countries (under the TEIA Convention). Reporting an event into eMARS is compulsory for EU Member States when a Seveso establishment is involved and the event meets the criteria of a "major accident" as defined by Annex VI of the Seveso III Directive (2012/18/EU). For non-EU OECD and UNECE countries reporting accidents to the eMARS database is voluntary. https://emars.jrc.ec.europa.eu/

- Removing inconsistencies or otherwise improving Emergency Response Plans and Emergency Procedures (5), by defining clear responsibilities for all actions and, as recommended in one case, the provision of simple checklists;
- Improving communications (4), between operators and control room or emergency control room, between external responders and emergency control room and between the on-site emergency controller (company) and the external emergency controller (local/state government);
- Additional fire fighting equipment and water capacity (4), in other cases the external fire service provided additional resources;
- Providing better warning alarms both on and off site (3), in some cases alarms were not sounded, partly due to confusion over who was responsible and in other cases alarms were not audible;
- Arranging access (3), for external responders (particularly if not arriving at the main gate), controlling unwanted access and ensuring that there is access (adequate space) on-site to provide cooling water or rescue;
- Evacuation, muster and roll call (3), including immediate escape for persons on scaffolding platforms, safe muster points known to all (including contractors), robust roll-call process including knowledge of those on emergency response crew;
- Ensuring sufficient personnel resources to respond to the emergency and continue operations (2), if not can other units be shut down safely?
- Improvements to training (2), were mentioned specifically but implied wherever improvements to planned responses were required; a suggested frequency of training in one case was for drills every 15 days;
- Minimise the number of people in a hazardous area (2), use remote supervision and only the number required for an effective safe response (when investigating normally a minimum of two is necessary);
- When hazardous operations are being undertaken have emergency responders and equipment on standby close to (but not at) the work site (1), e.g. work on live flare systems;
- Ensure that the instrument ranges cover the whole range for both normal and expected upset conditions (1); e.g. level, temperature, pressure, in particular to enable diagnosis and identification;
- Provide emergency power (1), in case response requires electricity (this appears to be a special case and not generally applicable as additional hazards may be introduced);
- Sometimes effective risk mitigation techniques are difficult to apply, e.g. foam to suppress vaporisation and extinguish fire may be blown by the wind and much larger quantities than anticipated are required;
- Plans should consider additional hazards to personnel that may be present (2), e.g. radioactive sources and asbestos.

Current practice in immediate response

The project carried out a survey of member organisations to ascertain the current commitment to emergency response planning and training. There was a wide variation in approach. Answers indicated a range of maturity, some very proactive in the levels of training and exercising with protection of personnel paramount but others were carrying out the minimum to satisfy regulations.

There are significant differences between the approaches onshore and offshore even within the oil and gas industry. There are a number of guidance documents which are accepted by the offshore industry as standard for the UK Continental Shelf (UKCS) including, Oil & Gas UK (2010a & b) and OPITO International (2016). These cover training and assessment of competence as well as planning for emergency response. Onshore industry guidance and standards are less useful, at least in the areas of immediate response, training and competence. EI (Energy Institute) (2012) guidance is available which although directed towards fire prevention and mitigation measures, has significant sections devoted to response which are relevant to loss of containment incidents whether or not they are ignited. Its key principles include:

- Rapid detection of loss of containment to enable effective incident response (including isolation) - section 3;
- Maintaining a focus on incident prevention but planning and training for emergencies – section 5.

Life safety is a clear priority and the response needs to consider the safety of responders as well as on and off-site personnel from the incident and potential escalation. Competence requirements and training are considered but the focus is on firefighting response and the equipment for it.

The guidance suggests that emergency "plans may consist of a three-tiered response with:

1. Installation operators as the first response.
2. Installation fire responders as the second response.
3. FRS (Fire and Rescue Service) or fire tugs (in the case of jetty incidents) etc. as the third response."

For this project only tiers 1 and 2 are relevant. The EI guidance gives five key principles for incident response:

- Evaluate the incident, ER tasks and persons/items at risk.
- Select response procedures and ensure competency.
- Assess response procedures and evaluate whether the risks are proportional to the benefits.
- Introduce additional risk reduction measures e.g. SCBA, PPE, Safety Officers, etc.
- Re-assess response procedures and additional risk reduction measures."

The guidance gives competence requirements for fire responders and managers but not for the initial actions by frontline operators. It does not assist with the formulation of response plans and frequency of training or competence assessment other than for fire teams. The guidance also addresses dynamic risk assessment but mainly in relation to fire.

There has been some relevant research by HSE (2001) which highlights the importance of the frequency, realism and detail of emergency exercises. "A defined structure of frequent small scale drills with less frequent large-scale simulations based on the site safety case or actual incidents is shown as good practice" in maintaining preparedness. Competence assurance was identified as another important factor when the level of success of response was assessed from exercises.

Actual behaviour in response to loss of containment indicates that there is a lack of understanding of the potential severity of the consequences of a loss of containment (extent of fire or explosion) and an expectation that leaks are always minor.

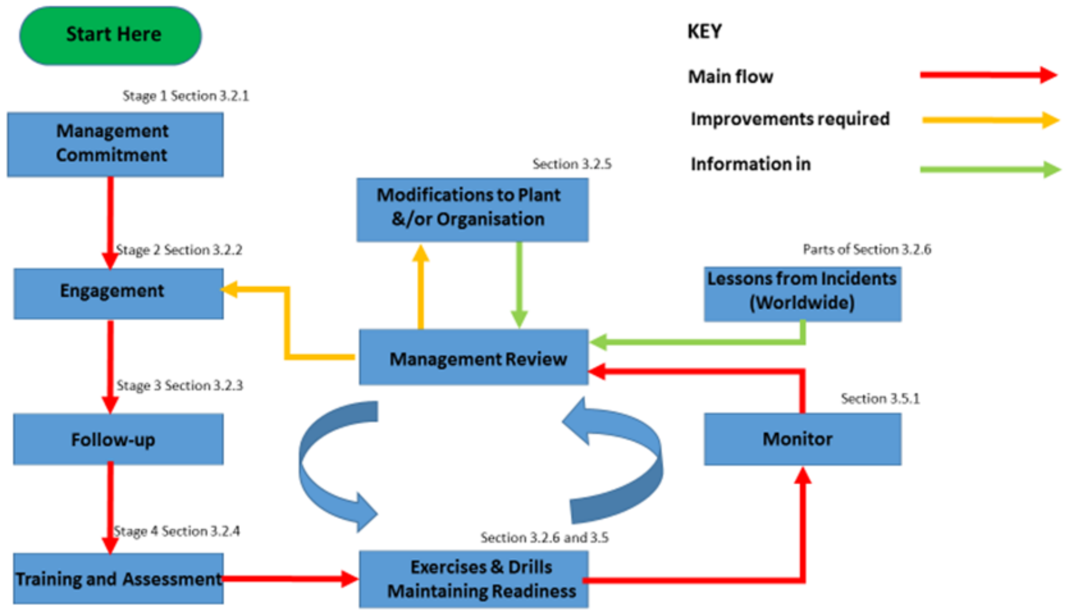
New Guidance

The outcome of the review has been production of new guidance for the whole process of designing emergency response procedures, training, exercises, competences assessment and feedback to improve the performance (EI 2017). Although the primary focus is improving the response to loss of containment, the process could be used for designing the response to all types of emergencies and for all phases of the response. It could also create opportunities for all personnel to be more engaged with the Safety Case / Safety Report and understand or even develop their own role in maintaining the safety of operations.

The process is outlined in Figure 1. The intention is that the process should follow the protection priority of "People, Environment, Assets and Reputation" (PEAR) and not allow production demands to influence actions or decision making over consideration of potential safety and environmental issues. Actions should be pre-planned and always designed to move the plant to a "safer state".

The process is assumed to start with the recognition that any existing system requires radical improvement. However, it is suggested that facilities with established and effective systems already in place but wishing to improve their response could follow the same steps.

Figure 1: Loss of containment response – implementation, design, training, competence and improvement



Design of emergency response procedures

The new guidance proposes a four-stage process to develop the response, including ensuring that the policy and objectives for response are clearly established with the support of the facility management team and their managers.

Stage 1: Management Commitment (Alignment of Leadership with Policy)
The Manager at each facility carries out an upward assessment of his/her Line Manager on Health, Safety and Environmental (HS&E) knowledge and approach, including their knowledge of potential major accident consequences identified in Safety Cases or Safety Reports. This will immediately give a strong message that Senior Management are open to challenge on these topics, wishing to change (if necessary) and willing to invest in HS&E improvement. The results are used as the basis for a one day or a half day seminar, that is externally facilitated, that would establish a common way forward on HS&E issue management. There should also be a survey of all the facility's personnel to establish whether they are, or feel, involved, in the preparation of the Offshore Safety Case / COMAH Safety Report (onshore); have they read it and do they understand their role in maintaining a state of safety? The Safety Case/Report should be seen as 'dynamic operational aid' for emergency response and should be the go-to reference point for possible events and their control methodologies. References to help generate a survey are given. The culture of the facility should be aligned with the corporate policy for safeguarding the health and safety of employees and others. One of the intentions of Stage 1 of the process is that all staff are aware and genuinely believe that safety takes priority even when financial circumstances put stress on resources. There are many examples of plants never re-opening after a major accident and their parent companies not surviving the consequential impacts. The results are likely to indicate where the actual response to loss of containment, (or other desired safety behaviour), may fall short of the desired actions. Managers will need to define corrective actions which may include showing leadership and changing their own behaviours or expectations.

Stage 1 is a potentially painful process, and will probably result in some unpleasant surprises for Senior Management. However, one of the most significant steps forward in safety in the past 20 years was made by a major operator in the North Sea by undertaking just such an exercise. This was undertaken in response to anecdotal information that the workforce, up to and including middle management, did not believe that Senior Management "walked the talk" as far as safety was concerned. This had the implication that safety attitudes had stalled and were not improving as senior management had thought. This was a contribution to the flat safety performance that was prevailing at the time. It required external intervention to effect the change which was successful.

The alignment of company policy, senior management and facility leadership team's approach to process safety and emergency response is followed by workshops to involve all relevant personnel in developing responses to loss of containment incidents and understanding their roles. (This is where the process could be expanded to review all actions required by individuals to ensure a facility operates safely – i.e. prevention and mitigation measures are in place and maintained).

Stage 2 Engagement (Communication and Design of Procedures)
A workshop (or series for larger facilities) for all the facility's staff but with focus on the operations teams. The agenda would be relevant to all aspects of process safety management, but specifically address loss of containment prevention and management. Staff should discuss: • the major accident hazards and scenarios in the Safety Report / Safety Case and whether they represent the range of accidents that could occur (including those with only on-site effects). • other scenarios raised in risk assessments, HAZOP, LOPA, etc. to be included in planning and training. • their individual contribution to the barriers (e.g. those required to meet the COMAH Regulations' 'all measures necessary' criterion) to prevent those loss of containment incidents accidents occurring. • time and the correct priorities to maintain the barriers, • skills and competencies to identify the hazards and carry out the related tasks on inspection, testing, maintenance and training or rehearsing for emergencies. • how loss of containment could occur, diagnosis of loss of containment incidents and the responses required. Staff should identify the "safer states" which should be aimed for when a major accident occurs, or at the first warning that one might be about to occur. This is particularly important for situations where an immediate shutdown (with associated venting and / or flaring) might not be considered a safe option. The safer state (i.e. the process conditions or plant status having a lower hazard potential) – no actions should lead to potential increase of risk. Note that a "safer state" may not be a total shut down but in the face of uncertainty the response should always be to move towards a known safe state using a planned response to an event to achieve this. If there is contradictory information, then it is necessary to define a 'safer state' whichever information is wrong. The objective of the workshops is to define an agreed programme for developing or improving emergency response procedures, actions and defining the skills and competencies required with the full understanding of all the participants. Attendees: Managers, Supervisors, Control Room Operators, Plant Operators, Plant Support Engineers and Process Safety specialists and Maintenance Managers and Engineers. Administrative staff should also be invited for awareness sessions and

to reinforce the cultural message. It is essential that frontline responders, i.e. the Control Room Operators and Plant / Field Operators attend.

The output from this stage would include:

- Identification of critical / significant (or limit of what may be "tolerable") leak criteria
- Strategy for responding to leaks including:
  - What risk assessments to do
  - When / how to investigate and when/how to involve engineering support
  - Criteria to initiate the emergency response plan
  - What fall-back arrangements should be in place
- Overarching principle of minimising risk to people and minimising numbers in the vicinity of any leak
- "Safer states" for each unit or section of plant where there may be an alternative to shut down or isolation
- Procedures required
- Roles involved where competencies need to be specified
- Major Accident scenarios from the Safety Report or Case for use in Emergency Response Planning

Stage 3 is where the principles identified in Stage 2 are developed into the specific procedures and training requirements which will include the initial plan for regular drills, exercises and refresher training.

Stage 3 Follow-up (Design of Training and Tools)

The workshops and follow-up embed a broad understanding of the response to a loss of containment incident, and this, with the provision of prompts (e.g. checklists) are the basis of procedures and definition of competency requirements.

However, to ensure that all staff remain familiar with requirements, formal training is required.

Examples are:

- Plant inductions should cover the steps to be taken on the identification of a loss of containment.
- Initial training in specific roles
- Regular HS&E meetings are to be used to discuss loss of containment events, preferably actual events.
- Operators and maintenance staff fully involved in development of emergency procedures.
- Exercises or drills should be conducted frequently and ensure that all staff rehearse key roles to maintain awareness and readiness.

Planning exercises involves amongst other topics:

- Choosing scenarios with major accident scenarios selected from the Safety Report or Safety Case
- Ensuring that the exercise includes testing effective decision making
- Designing exercises to test a variety of issues during the cycle between revisions
- Including realistic minor and major exercises
- Selecting issues to focus on, relevant to planned activities including operational organisation changes
- Allowing sufficient time for discussions, and debrief

Other training should be based on needs identified by feedback from competence assessments, exercises and manager appraisal.

The development of response to loss of containment is completed with the initial training and assessment of competence.

Stage 4 Training and assessment (Delivery)

Special training for the staff who will be called upon to make the key decisions, and to do so promptly, effectively and efficiently, who will be:

- The CROs; (informed by outside operators / field operators / maintenance staff as well as instrumented systems), possibly led by a Shift Team Leader
- The senior person present, i.e. permanent presence Supervisor/Manager, OIM/Deputy OIM or Site Shift Manager;
- The Plant Manager and/or Deputy who, out-of-hours, are probably going to be on-call.

These positions and their deputies should receive enhanced training, coaching and 'formal' assessment in response to emergencies, specifically in, but not confined to, loss of containment events. Training must include instruction and practice in how to make decisions. Exercises should be defined at different levels – shift and management.

Competence standards and assessment criteria are set, which must be met for staff to continue in their role. For offshore roles, these are clearly set out in OPITO 2016 but for offshore facility specific requirements can be defined using guidance in Cogent/UKPIA 2012, Flin 2005, EI 2014 and EI 2012

All other senior managers and executives should receive emergency response training appropriate to their role. Demonstrated competence in their responsibilities should be a requirement for confirmation of their appointments.

The guidance includes suggestions on training content and duration.

Refresher Training and maintaining readiness

Once the procedures are defined and staff trained it is necessary to maintain a state of readiness and ensure that personnel are prepared to follow the intended actions in an emergency. It is also important to ensure that the procedures remain appropriate in the event of any changes to plant or organisation. Operators experience 'normal operational states' for most of their working lives and when abnormalities arise should act with knowledge, instinct and confidence formed during their participation in training, drills and exercises

To ensure that response to loss of containment is instinctive and reactions are well rehearsed all Control Room Operators and Outside (or Field) Operators (where appropriate) and their supervisors and managers should receive refresher training, including reassessment of competence. The periods between re-training and assessment should reflect an organisation's assessment of each individual's exposure to emergency response requirements which should include their participation in drills and exercises. For example, some companies have described tasks / activities that take place less than once every 90 days as non-routine and requiring rehearsal or refresher training; therefore, they may set a maximum interval of 90 days between each individual's exposure[2] to emergency response requirements.

The frequency should also take account of team changes through staff turnover, modifications to plant and organisations and any other situation that is important in maintaining a state of readiness

If a facility holds one major accident response exercise per year, then each shift may only get the experience once every 5 years. Each shift (and therefore all staff involved in response) should have at least one simulation per year and further refresher training on appropriate responses, covering the range of emergency actions expected of them, to maintain awareness and readiness. By way of comparison, airline pilots have about 6 days training and assessment per year related to safety. The suggested emergency response training for frontline staff would be less than half of that but then other safety topics should be included to make up 6 days, e.g. Control of Work, Permit to Work, Confined Space procedures, maintenance of safety critical equipment and assessment of safety critical tasks.

Facilities should also have arrangements to learn from their own near misses and incidents, at other sites as well as their own. These should be used to check and improve the emergency response arrangements.

Exercises and drills (maintaining readiness)
All staff should receive annual reinforcement of basic induction training which will ensure that they are informed of any changes that have been introduced. Otherwise the frequency of refresher training depends upon the review of exercises and competence assessment of individuals, which should be reviewed annually. Refresher training should include extended tool box talks, emergency drills, desktop / computer simulation exercises and full scale exercises. Assessment of readiness to respond correctly to emergencies should be part of the annual appraisal of all staff, supported by specific assessment of performance during exercises. Where plant modifications, or lessons learned (from incidents or exercises), impact on emergency response these changes should be included in the refresher training cycle, managed through the site's 'management of change' process. Note that offshore routine drills, such as mustering are practiced weekly, specific exercises are scheduled once a fortnight involving specific responses, such as running out hoses or responding to flange leaks, the schedule is designed to cover each of the emergency processes for all personnel expected to respond. The typical duration of these "minor" exercises is 45 minutes. Major exercises which also test the Command and Control arrangements and liaison with external agencies take place less frequently (typically once per year), using events taken from the major accident hazards scenarios.

Monitor and review

All the training should be monitored and reviewed in terms of the feedback from participants and the outcomes of drills and exercises. This should be collated with assessment of individual performance to identify where improvements are needed. Note that the process defined in Figure 1 envisages that improvements might be required in hardware, safety systems or organisation as well as procedures. The nature and frequency of training may also be modified on the basis of the assessment of competence and readiness to respond in the desired manner.

[2] "Exposure" could range from review of procedures, through toolbox talk reminders up to involvement in an exercise. Frequency and depth to be set in the light of competence assessment results.

One of the potential outcomes of assessment is that some staff, while excellent managers or Supervisors, may not be capable of the attitude required, and Command and Control approach demanded by an emergency. This is a recognised issue for organisations where 'technical' capability determines progression without the forethought to assess command and control capability as a significant part of internal staff development or a key quality required of candidates for external recruitment into 'new' roles.

Cullen (1990) states "The conventional selection and training of Offshore Installation Managers is no guarantee of ability to cope, if the man himself is not able in the end to take critical decisions and lead those under his command in a time of extreme stress".

It must be accepted that if the onshore industry elects to follow the offshore industry in implementing assessments for those who would be in a position to manage an emergency, firstly, some may not be successful and secondly, selection processes will have to adapt accordingly.

Response to a confirmed loss of containment

The guidance explains the overall response and the toolkit provides actions for the frontline roles of field operators, control room operators and immediate supervisor or team leader on-shift. The action lists in the toolkit are based on the following sequence of response:

Establish product. If hazardous and significant then progress as follows:

1. Initiate a plant wide communication to withdraw/evacuate all personnel to the pre-determined place of safety and mustering point.
2. If not initiated automatically, isolate relevant section of the process or the whole plant as required.
3. If chemical, access the appropriate SDS (Safety Data Sheet, formerly MSDS).
4. Establish if product is ignitable[3]. (If hydrocarbon, assume yes; for other chemicals, review information in SDS).
5. If not initiated automatically, depressurise plant, confirming first that a route to flare or vent exists that has not been compromised by the event.
6. If LOC product is ignitable[3], isolate all sources of ignition, e.g. electrical power, hot exhausts, internal combustion engines.
7. If company policy allows, and the facilities exist, initiate local deluge. Note that some chemicals should not be mixed with water.
8. If company policy allows, and the facilities exist, initiate deluge in adjacent areas. Note that some chemicals should not be mixed with water.
9. Establish wind direction and potential impact on anything or anyone downwind.
10. Shut-down any heating, ventilation or air-conditioning (HVAC) system that may draw in the leaking product anywhere within the maximum extent of a toxic or flammable vapour cloud.
11. Assess the risk to the mustering location from the event and move personnel if necessary.
12. Move all personnel from downwind locations. This may include adjacent premises and other business locations.
13. If applicable, advise contact list on cold venting.
14. If cold venting, establish impact of wind direction.
15. Advise authorities.
16. Brief assembling responding teams. Default is for teams to hold position and not deploy.
17. Identify any missing persons and establish last known locations.
18. Initiate plant wide communications to missing persons taking care with phraseology.
19. Interrogate permit-to-work system to establish possible persons involved, alignment with any missing persons, and any activity that was taking place.
20. If there are missing persons, and last known positions suggest they may be involved in the event, set up medical handling facilities, e.g. triage, external fire and rescue resources etc. Prepare casualty handing, e.g. stretcher teams.
21. If there are trapped persons, establish the risk (dynamic risk assessment) of them staying where they are and set up an ongoing communication channel with them.

[3] The term ignitable is used to describe substances which are officially classed as "flammable" plus those with higher flash points that may ignite when released as a spray (aerosol) or at high temperature.

22. If a rescue is expected, brief responding teams as to preparation required. Default is for teams to hold and not to deploy.
23. Establish any potential impact on the environment and whether or not containment systems, bunds etc., are sufficient and are coping. Note that if deluge has be initiated, bunding may be insufficient.

If the release is deemed "not significant" then no immediate action should be undertaken. Any intrusive investigation is carried out safely and under controlled conditions after a suitable risk assessment.

Conclusions

Stakeholder workshop findings

The initial draft of the guidance and toolkit was presented to a representative group of process safety managers from on and offshore oil and gas, chemical and nuclear industries. There was uniform agreement that the four-stage development process, initial and refresher training were a sound basis for the guidance. There was some pushback from the onshore industry on the details particularly the time to be spent on maintaining readiness and expectations of isolation and shutdown systems. The authors maintain that the time, trouble and effort required for initial and refresher training is not considered excessive when considering the costs of casualties, damage, lost production, time, trouble and effort associated with loss of containment accidents which have not been managed well. This is a similar argument to the justification for a precautionary shutdown which has costs many orders of magnitude lower than the costs of an accident.

The guidance and toolkit was revised following the useful, detailed comments, particularly on the contents of checklists.

Guidance and toolkit

The guidance addresses concerns that have arisen following major incidents where operators and responders have been put in danger through not having a clear message on the priority of protecting people and taking unplanned actions without knowledge of the potential scale of hazards from a release.

The method for designing responses to loss of containment (and other emergencies) ensures a consistent approach to the safety of personnel and training safe behaviours. The need for improvement in response can be identified together with the training of individuals, reviewing procedures and ensuring that operational teams are provided with the means and support to return plant to a "safe state".

Acknowledgement

The authors wish to acknowledge the contributions of the members of the Energy Institute's working group, the participants in the stakeholder workshop and those commenting on the draft guidance and toolkit. The Energy Institute's Technical Partners and Technical Company Members are thanked for funding the technical development project.

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