Safety in Focus

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Jet Fires: A Destructive Force

By Faisal A. Al-Basaffar, Planning & Technical Services Division, Loss Prevention Department

At approximately 1:20 p.m. on September 21, 1992, a jet of flame (jet fire) erupted from a manhole on the side of a separation vessel at a chemical plant in the UK. The power of the flame severely damaged a control room and killed five employees in an office building located 50 m away.

What happened

A process vessel, used to separate organic liquid in batches, was being cleaned to remove 30 years of accumulated sludge. The sludge was not analyzed nor was the atmosphere inside the vessel checked for the presence of flammable vapors. It was assumed that the material was a thermally stable tar.

When heat was applied to the sludge (for about three hours) it generated a spontaneous, self-heating (exothermic) reaction that resulted in the ignition of the accumulated flammable gases present inside the vessel. (As it turned out, the assumed thermally stable tar was an unstable, tar-like liquid.)

As a result, a jet fire erupted from the manhole that lasted for one minute and travelled horizontally over a 50 m distance. The manhole cover was propelled into the center of the plant control building and the flame breached and passed through the building into the main office block. Tragically, inside the control room, which was located 25 m from the manhole, five employees died. The flame shattered the windows of the main office block (a four-story office building) and ignited some rooms. There were 63 employees in the office building at the time.

What went wrong

This incident could have been prevented if the risks associated with this nonroutine cleaning operation had been accurately assessed and appropriate precautions were taken. The management system failures included:

- A poorly developed or nonexistent maintenance procedure for this nonroutine task.
- No hazard identification or analysis of the sludge material was performed.
- Inadequately trained employees to perform the necessary tasks (e.g., they knew little about thermal instability, chemical reactions and product testing).
- Poor equipment design (e.g., location of the temperature probe inside the vessel).
- No work permit was issued for removing the sludge and no gas testing was conducted.
- Close proximity of occupied buildings within the plant facility.
- Inadequate material selection for the construction of critical buildings.
- Inadequate emergency response and evacuation plans affecting the means of escape in the main office block.

Five people killed, nearly 200 people injured, a control room and four-story office building gutted. A devastating outcome that could have been prevented if the proper design, engineering and administrative controls had been developed and applied.

Why Care for Off-Job Safety?

Our unique role in the community and strong interest in off-job safety makes Saudi Aramco stand out among its industry peers. Indeed the company has a long history of actively promoting the well-being and safety of its employees off the job. Why?

By Rea Kelamis, Planning & Technical Services Division, Loss Prevention Department

Costs of off-job incidents

Over the years, off-job injuries and fatalities have caused pain and agony to employees and their families, and also caused substantial loss of productivity for Saudi Aramco. During the decade of 2003 to 2012, our company suffered a total of 253 fatalities. Of these, 19 occurred at work and 234 off the job. In 2012, we lost 31 employees — all to off-job injuries! These facts highlight the need to address off-job safety and improve behaviors when away from work. But the challenge is motivation. While at work employees are guided by a number of policies, standards and safe operating practices that our company sets and enforces; when they are away from work the behaviors they demonstrate may not be a result of similar motivators but rather personal values.

Value of off-job safety programs

Off-job safety is an extension of our *Safety* core value. We can only uphold our corporate safety value when we improve our safe behaviors when at work, and most importantly, away from work — where most of our incidents and injuries take place. A substantial reduction in our off-job incidents and injuries will be an undisputed indication that we have been successful.

We promote off-job safety because:

- Employees are more likely to suffer an injury or fatality while off rather than on the job.
- It's the right thing to do. While we have a legal responsibility to prevent occupational injuries and deaths, we have a moral responsibility to try and prevent injuries off the job.
- Injury, illness and death off the job are as emotionally and financially costly to employees and their families as injury, illness and death on the job.
- Employees understand they are valued when the company demonstrates concern and care for their well-being.
- It helps promote safe behaviors throughout the nearby communities.
- It makes business sense. Operating costs and production deadlines are as affected when employees are injured away from work as when employee injuries occur on the job.

Saudi Aramco understands the importance of encouraging employees to apply the safe practices they learn at work when they are away from work. By doing so, employees reduce off-job injuries, absenteeism and medical costs, but most importantly, it proves to employees that their health and safety are important.

Off-job safety program

A well-developed and implemented off-job safety program can help reduce off-job incidents the same way that traditional safety programs reduce occupational incidents. Saudi Aramco's unique (to the oil and gas industry) program involves recording, analyzing and reporting off-job injury data, and motivating employees to use safe behaviors wherever they are — at home, on the road and at play.

Employees discover that they themselves have a vested interest in adopting the safe behaviors they learn on the job to their lives away from work. Their adherence to off-job safety standards helps to protect their health, safety and well-being. In turn, they set the example and empower their family members to make safe choices, which then influences the larger community in which they live.

Successful strategy

Successful off-job safety programs are strategically recognized as being inseparable from on-job safety programs as they both demonstrate the company's core Safety value. It is an inward-to-outward strategy.

The Saudi Aramco Safety Management System (SMS) consists of 11 elements that collectively define specific objectives and performance expectations to help

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deliver world-class safety performance. Given the company's unique culture, structure and role in the community, Element 10 of the SMS, "Community Awareness and Off-the-Job Safety," sets the off-job safety of employees and their families as a key priority, and emphasizes the company's role to provide relevant safety, health and environmental information and to educate the public. It provides a link between on-job and off-job safety, and stresses the importance of extending safety behaviors beyond the time they spend on the job.

Element 10 embraces a growing expectation that each person is responsible for safety — as an individual and as part of an organization, as an employee and as a member of a community. Safe behaviors are practiced at all times. These are not behaviors that employees practice only at work and leave behind at the end of the work day. The corporate *Safety* value is predicated on the basis that employees collectively embrace safety as a personal value and apply it on and off the job.

Rig Coming through!

By Reinaldo Polanco Ramirez, Dhahran Area Loss Prevention Division

Figure 1. Examples of rig moves

Moving a huge piece of equipment safely requires careful planning. This is especially true when moving drilling rigs and equipment (known as "rig moves"). A rig move can take place in many different environments: through heavy traffic highways, skid roads, open desert, on barges through freshwater rivers, or in open seas (offshore). Every move has its own hazards and risks, so a detailed and specific plan must be prepared for each rig and every move.

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For Saudi Aramco rig moves, three key players are involved:

- The Saudi Aramco operations foreman — The person who represents Saudi Aramco on the rig.
- The contractor drilling supervisor — The person responsible for the rig at all times, except when it is moving between sites.
- The contractor rig move supervisor — The person responsible for moving the rig.

They each have different responsibilities, but they must all work together if the rig move is to be successful.

An effective onshore rig move normally requires five stages.

Rig move preparation

Preparation to move the rig takes place well before the move begins. Drilling departments set schedules for drill sites a year or more in advance. Every day a rig is not drilling — such as during a move — costs the company in terms of production time.

Location and road surveys

A team visits the location and scouts the proposed route to identify:

- Power lines on the road to determine if the clearances underneath are sufficient.
- Pipeline, flowline or trunkline crossings.
- Topography and ground conditions (e.g., sabka, loose sand, wadi) that could jeopardize the safe travel of heavy, high and wide equipment.

Survey verification

The operations foreman visits the new location at least seven days before the planned rig move. Representatives from the Transportation and Power Operations departments and the production organizations also attend. Any unsafe condition or logistical problem observed must be resolved by the responsible organization prior to the rig move. A report, including a map and a checklist of identified hazards, is signed by all attendees.

Rig move plan

Once the location and routes are approved, a rig move plan is prepared identifying necessary safety measures and any special permits required from government agencies.

The plan must describe and identify:

- Equipment that can be sent in advance to the new location. Premoving some equipment can save significant time and money.
- Load list with dimensions and weights.
- Wide loads needed for the convoy.
- Loads and their sequence. It is important that the loads arrive in a certain order so the rig can be assembled efficiently. Such equipment is not easy to move, so each part must be available when and where it is needed.
- Heavy equipment required for the specific rig configuration.
- Lifting equipment required and the critical lift plans.

Common hazards

Transporting a huge rig and all its separate parts requires careful logistical planning. Common incidents include:

- Unbalanced loads causing rollovers on highways or skid roads.
- Unsecured loads falling off or shifting and crushing the truck, cabin or other vehicles.
- High loads contacting power lines or bridges.
- Crane booms that are not lowered properly.
- Wide loads restricting the vision of other drivers.

A premove meeting is held with the operations foreman, drilling supervisor, wellsites engineer, rig move supervisor, convoy leaders and heavy equipment operators to review the plan and ensure the following minimum safety measures are followed:

- Daily review of the rig move plan to identify and manage hazards.
- Daily inspections at the beginning of each day or move to ensure transportation and lifting equipment are in good and safe condition, and that each load is properly positioned and secured.
- Crane operators and truck drivers are competent and certified.
- Personnel with limited experience are identified and assigned tasks appropriate to their experience and ability.

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- The weather is suitable. No rig moves should be made in foggy, rainy or dusty weather where visibility is less than 100 m.
- Daylight hours are noted. No loading or moving of oversize loads is allowed at night.
- Proper communication devices (e.g., radios and mobile or satellite phones) are tested and made available, and emergency contact information is up-to-date.
- Medical staff, emergency equipment and MEDEVAC (evacuating a sick or injured person by ambulance or helicopter) procedures are available wherever there are drilling rig workers.
- Adequate logistic support is available (e.g., catering services at both locations during the rig move).

The operations foreman registers all activities and provides a daily move report to his department superintendent.

Rig move review

After every move, the drilling superintendent, operations engineer, drilling rig supervisors and rig move supervisor review the move. This is to note any incidents, near misses, high risk potentials (an incident where under different, plausible circumstances a fatality might have occurred) or other problems, as well as learning points that could be incorporated in a Rig Move Manual.

Summary

Rig move operations can be safely performed and the associated costs efficiently managed. Rig moves can be completed free of injuries, property damage or environmental incidents if a good plan is developed; if all involved personnel follow the plan; and, most importantly, if the operations management team remains involved in these actions and provides adequate training and resources.

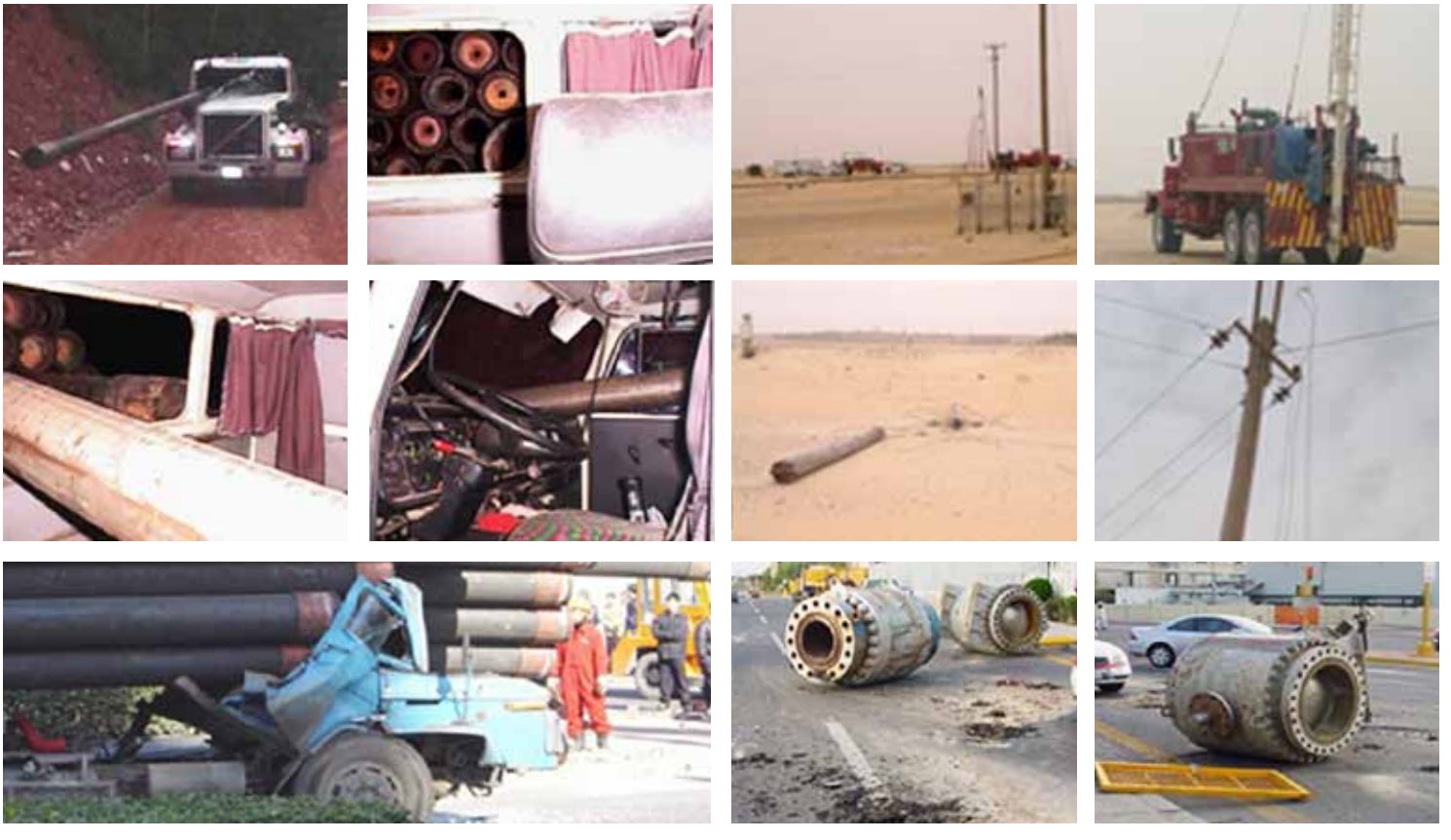
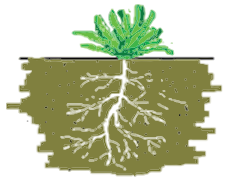


Figure 2. Industry incidents show that without careful planning, a rig move can be both deadly and costly

Root Cause — What Does it Really Mean?



By Dennis P. Nolan, Fire Prevention and Project Support Division, Loss Prevention Department

An employee slips on a wet floor and breaks a leg. The employee's supervisor must determine why it happened and how to prevent a similar incident from happening to someone else. The supervisor must identify the cause or, more specifically, the real underlying reason or "root" cause of the incident. But what does root cause really mean and how can it be determined?

Many might think the cause of this injury was a janitor's failure to adequately wipe up the spill or to place caution signs warning of the wet floor. Case closed — the cause was identified and the investigation was successful.

This initial conclusion or "causal" factor does not identify the real reasons the incident occurred — the root causes. Did the janitor inspect to see if the floor was wet or did he not realize that someone might slip on the wet surface? In other words, the root causes of this incident could be attributed to:

- Less than adequate recognition of the hazard posed by a wet floor.
- Lack of equipment to clean a spill.
- Failure of management to educate the janitor in the hazards associated with the job.
- Failure to establish and enforce routine inspections.

Incident investigations are not fault finding exercises. Root causes are the most basic factors that can be reasonably identified that management has the ability to eliminate, control or correct, and for which effective recommendations for preventing recurrence can be determined. The key is to remember that root causes refer to management system failures.

Causal factors — the symptoms, substandard acts or conditions — are usually apparent. However, to identify the root causes takes some probing. To facilitate the identification process, a root cause analysis (RCA) is often used. The RCA helps to ascertain why problems occur and what can be done to correct them so that the same, similar and other seemingly unrelated problems with shared root causes do not occur in the future.

A common RCA tool is the root cause map (see Figure 1). It is a decision-making diagram that is typically divided into two sections. The left side is used to identify and categorize the causal factors associated with equipment failures (e.g., design input and output, design review verification, equipment records, calibration programs, preventive maintenance programs, inspection and testing programs, and administrative management systems). The right side is used to identify and categorize causal factors related to personnel (e.g., human factors engineering, procedures, training, supervision, communications and personal performance). The two sides of the map are not mutually exclusive.

Once the causal factors are identified, the "5 Why" technique is then used to determine the root causes by asking who, what, when, where and how for each of the identified factors.

Analyzing systems to identify, prioritize and correct potential hazards is a key to preventing future incidents. The RCA process seeks to ensure that the safeguards are in place and functioning to reduce risks to acceptable levels and to reveal the true causes of an incident. The RCA may also be used as a proactive method to forecast or predict probable events before they occur.

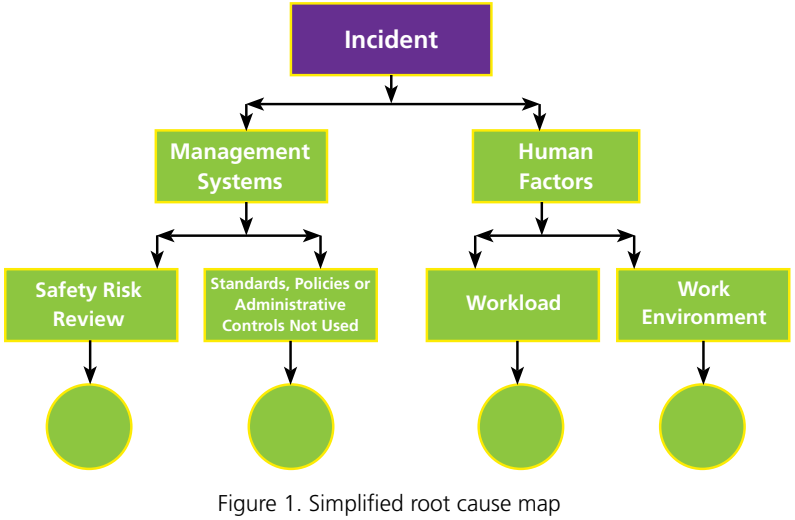


Figure 1. Simplified root cause map

Clean out the Tank!

By Saleh S. Al-Shaikh, Jeddah Area Loss Prevention Division

In a hydrocarbon storage facility, tank cleaning is usually the first phase of the testing and inspection (T&I) process. It involves confined space entry and workers may be exposed to a wide spectrum of hazards. Some of these hazards may not be readily apparent, others may not be present at all times; however, failure to recognize and control them could result in a disaster.

Preliminary precautions

Each storage tank must be assessed before work can begin. The first considerations are what type of product the tank held and how much residual material might still be inside. A visual inspection determines both the physical condition of the tank and the surrounding area, and the precautions needed. All sources of ignition must be controlled, so in most cases nearby roads are barricaded to keep vehicles and equipment clear until the area is tested. Lights and other electrical equipment near the tank should be explosion-proof and meet company standards.

Preparing the tank inside and out

The contents of the tank are emptied and pipes should be positively isolated (i.e., blinded or disconnected). These blinds must withstand the maximum pressure which might be exerted, so neither liquids nor vapors can enter.

Different methods are used for getting rid of the vapors already present in a tank. With mechanical ventilation, air is blown into the lower portion of the tank allowing it to exhaust or exit out the top. Natural ventilation, where the roof and shell manholes are removed and vapors escape through air movement, may be used if there is no potential for a hazardous atmosphere to develop inside the tank, nor for flammable vapors to drift in the atmosphere to a possible source of ignition.

Entry and cleaning

After the preparations and gas testing have been done, personnel can enter the tank. They need to be vigilant as harmful vapors or oxygen deficiency cannot be detected by smell, visual inspection or judgment, so atmospheric testing should be done throughout the cleaning operation. Employees who are inside the tank should wear safety harnesses and lifelines while a trained person must be on standby outside the tank to assist in the event of an emergency.

For any work outside on the tank roof, planks are laid as walkways, and full body harnesses for fall protection are needed. Finally, after all the sludge is removed and the tank has been thoroughly cleaned, the tank can be inspected, repaired if necessary, and returned to service.

Tank cleaning is a high-risk operation. By carefully following the established procedures and taking all safety precautions, the task can be accomplished safely.

Resources

Resources available at Loss Prevention's homepage: http://lp.aramco.com.sa

1. Safety Films available from the LPD Film Library:

- 100.082 – Hazard Recognition and Control
- 100.174 – Summer Sports: Safety Wins
- 900.521 – Petroleum Storage Tanks: Container Emergencies
- 900.816 – Safety in Drilling, Milling and Boring Operations
- 901.104 – Off-the-Job Safety

2. E-Learning Courses

- Hazard Recognition
- Injury Reporting and Investigation

3. Special Publications

- Visit LPD's special page dedicated to the Bringing Safety Home Safety Theme at:http://lp.aramco.com.sa/bringingsafetyhome and take the knowledge quiz for a chance to win a valuable prize.

4. References

- Saudi Aramco *Safety Handbook*
- General Instruction (GI) 6.025, *Control of Remote Area Travel and Search/Rescue Procedures*
- Health and Safety Executive, "The Fire at Hickson & Welch Limited, Castleford on 21st September, 1992," International Standard Book Number (ISBN): 0 71 760 702 X, 1994.

5. SafetySmart™

- The international reference site SafetySmart™ for videos, PowerPoint presentations, safety talks, and articles on the topics covered in this issue. This site is available through a special link on LPD's homepage at: *http://www.safetysmart.com/safetysmart/Learner.aspx?success*

The editorial staff welcomes readers' comments and ideas. Please email your suggestions to SafetyinFocus@aramco.com or mail them to *Safety in Focus*, Saudi Aramco Loss Prevention Department, A-117, Building 3150, LIP, Dhahran 31311, Saudi Arabia or call 872-8868.

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