Activity 1: Systems of Safety: The BP Disaster

Purpose

To introduce the concept of Systems of Safety and accident prevention.

This Activity has two tasks.

Task 1

Factsheet Reading Method for Task 1.

The Small Group Activity Method places workers at the center of the learning experience. It is designed to draw on two bodies of knowledge: 1) the knowledge and experiences workers bring into the room and 2) the factsheets contained in your workbooks.

The factsheet method, described below, builds upon this knowledge through the introduction of new ideas and concepts. The process is as follows:

First, select a scribe for this task.

Each of you will be assigned a small number of factsheets to read. You will then share this new information with your table. The idea is for each of you to take ownership and responsibility for the information contained in your factsheets and to describe it to the others in your group.

Your trainer will assign your individual factsheets in the following way: Starting with the scribe and moving to the left, count out loud from 1 to 8. Keep going around the table until all numbers (factsheets) are distributed. For example, if there are four people at your table, the scribe will have self-assigned Factsheets 1 and 5; the person to their left will be responsible for Factsheets 2 and 6, etc. The numbers that you have assigned yourself correspond to Factsheets 1 through 8 on the following pages.

Once everyone has read their assigned factsheets individually, your scribe will go around the table and ask each of you to explain to the rest of your group what you have learned. No notes need to be taken during this discussion. The factsheets should be explained in the order they were assigned (1 through 8), as many times factsheets build on previous factsheets. Once this process is complete, your trainer will read the scenario and the task. In this way we all start at the same place and with the same information.

1. What Are Systems of Safety?

Systems of Safety are proactive systems that actively seek to identify, control and/or eliminate workplace hazards.

Let's look at an incident where a worker bumped his head on a low pipe. How could this hazard be addressed by each of our Systems of Safety? (See the next six factsheets.)

2. The Personal Protective Factors System

1. Personal Decision-making and Actions

- Look and think critically at the workplace;
- Work collectively to identify hazards; and
- Contribute ideas, experience and know-how that will lead to correcting the system's flaws.

2. Personal Protective Equipment (PPE) and Devices

- Wear PPE as necessary and required when higher levels of protection are not feasible.

3. Stop Work Authority

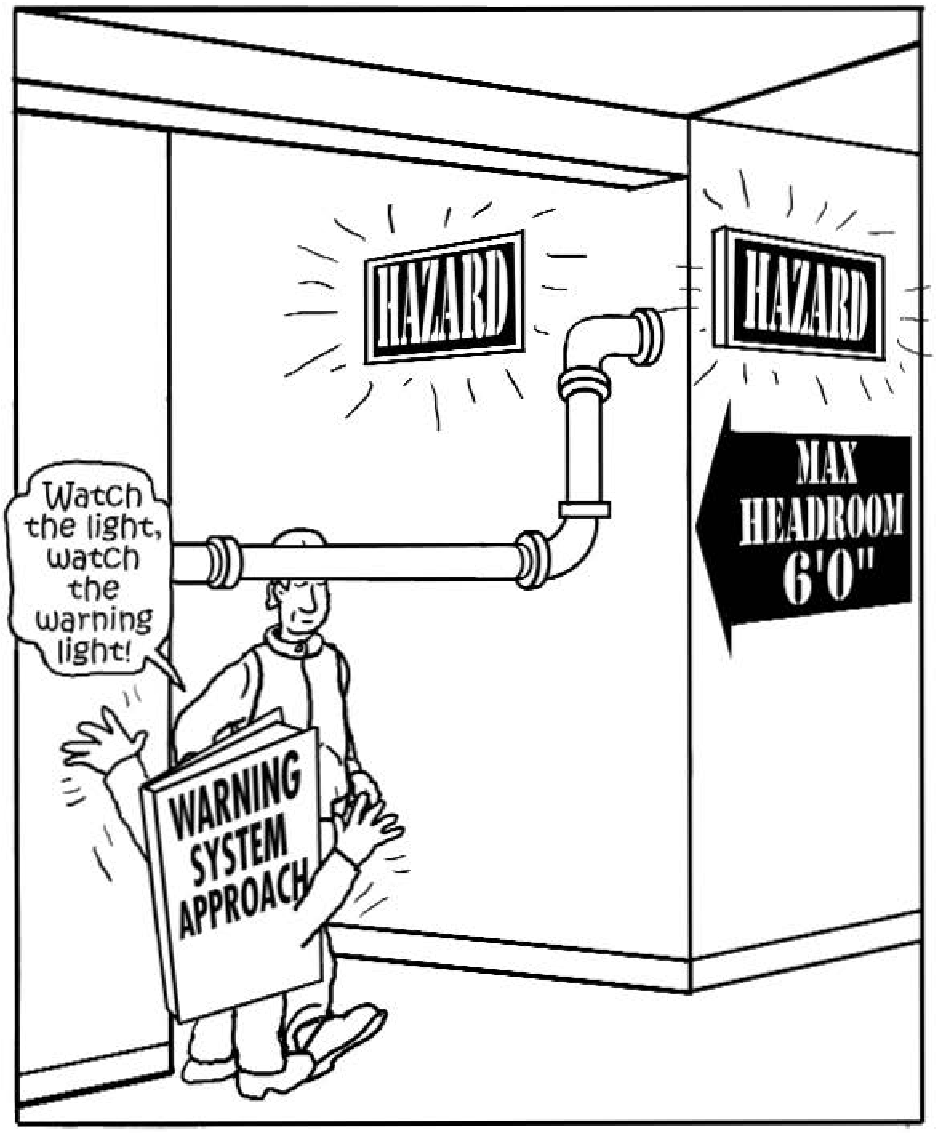
- Authority is given to all individuals; and they are encouraged to stop work, equipment or processes due to unsafe conditions until a thorough Hazard Analysis can be performed.

3. The Training and Procedures System

The operation and maintenance of processes that are dangerous require a system of written procedures and training. The greater the hazard, the greater is the need for Training and Procedures.

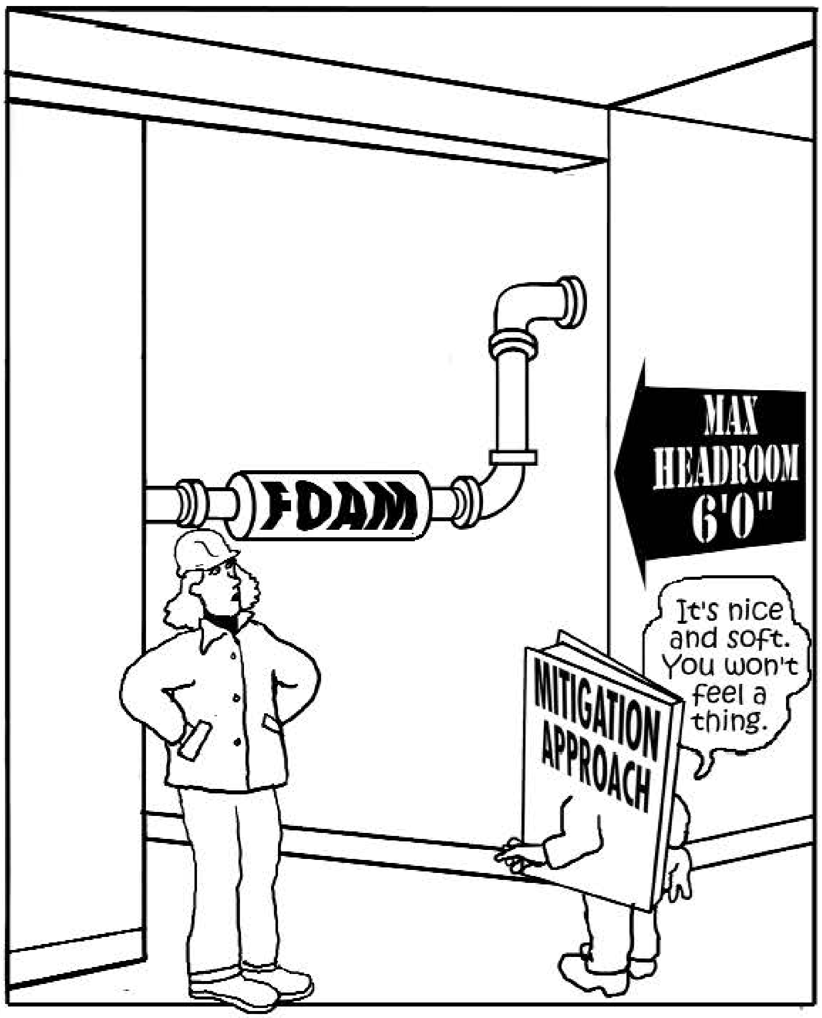
4. The Warning System

The Warning System of Safety includes the use of devices that warn of a dangerous or potentially dangerous situation. These devices require a person's intervention to control or mitigate the hazardous situation.



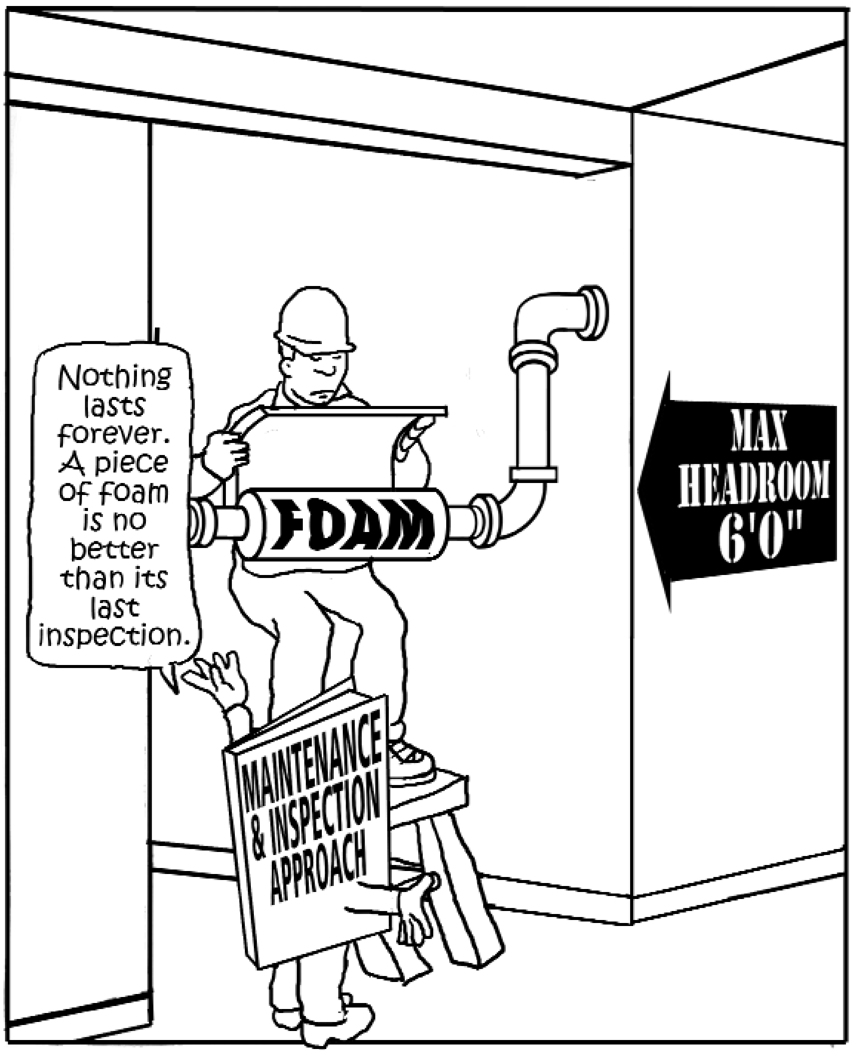
5. The Mitigation System

The Mitigation System of Safety involves the use of equipment that automatically acts to control or reduce the harmful consequences of hazardous incidents. Mitigation should be automatic and reliable.



6. The Maintenance and Inspection System

Properly designed equipment can turn into unsafe junk if it isn't properly maintained, inspected and repaired. If the phrase "if it ain't broke, don't fix it" is used within a workplace, the Maintenance and Inspection System is a failure. If you don't use preventive maintenance, then you end up doing breakdown maintenance.



7. Design and Engineering System of Safety

A central purpose of the Design System of Safety is to *eliminate hazards* through the selection of safe or low-risk processes and chemicals whenever possible.

One example of good design safety is the substitution of a less hazardous chemical such as sodium hypo-chlorite (bleach), for chlorine in treating cooling water. A release of toxic chlorine gas can travel in the wind for miles, whereas a spill of bleach is inherently less dangerous.

8. Eliminate the Hazard with the Design and Engineering System of Safety

You can design and engineer within any System of Safety; but a true Design and Engineering fix is the one which eliminates the hazard. For example: A worker is exposed through inhalation to a hazardous chemical which was being used in a cleaning process. The worker's respirator leaked. Suggested fixes recommended were:

1. **Design** and make a new respirator for the worker to wear. Is this an effort to eliminate the hazard? **No**! It is a fix in the Personal Protective Factors System of Safety.

2. **Design** a new procedure which makes it less likely that the worker will be exposed. Is this an effort to eliminate the hazard? **No**! It is a fix in the Training and Procedures System of Safety.

3. **Design** a warning system to alert the worker when the concentration of the chemical reaches a certain point. Is this an effort to eliminate the hazard? **No!** It is a fix in the Warning Devices System of Safety.

4. **Design** a better ventilation system which will remove most of the dangerous fumes. Is this an effort to eliminate the hazard? **No**! It is a fix in the Mitigation System of Safety.

5. **Design** a better maintenance and inspection program to maintain the ventilation system, keep down tripping and slipping hazards and make the job safer overall. Is this an effort to eliminate the hazard? **No**! It is a fix in the Maintenance and Inspection System of Safety.

6. **Design** the cleaning process to use a cleaning agent that is not dangerous to workers. Is this an effort to eliminate the hazard? **Yes!** It is a fix in the Design and Engineering System of Safety.

Task 1 *(continued)*

Purpose Restated: To introduce the concept of Systems of Safety and accident prevention.

Scenario:

In the early 1970s, child safety experts found themselves in the midst of a serious problem. A growing number of children were being poisoned by accidental ingestion of prescription drugs. The numbers had begun to increase after World War II as these medications became more common in the home.

The experts tried different options to control the hazard:

- National advertising campaigns were launched on radio and television to teach parents about the importance of keeping medications away from children.
- Schools held special presentations for young school-age children to teach them about the hazards of medicines.
- Cabinet latches to prevent access to medicines and other harmful chemicals were developed and put on the market.
- Special warning messages were placed on medicine container labels.

While the incidence of children accidentally ingesting medications slowed after these efforts, deaths still continued to rise. It was not until the “childproof cap” was introduced that the incident rate dropped dramatically.

continued

Task 1 *(continued)*

Task:

Now that you have reviewed Factsheets 1 through 8, discuss the following questions with members of your group. Select a scribe to report your answers back to the class.

1. Analyze the actions taken to eliminate this hazard. With which System of Safety did the action attempt to deal? Be sure and give your reasons.

Action	SOS Targeted (one for each action)
1. National Advertising Campaign	A. Warning Devices B. Training and Procedures
2. Childproof Caps	A. Design and Engineering B. Mitigation Devices
3. Warning Labels	A. Warning Devices B. Training and Procedures
4. Cabinet Latches	A. Design and Engineering B. Mitigation Devices
5. School Presentations	A. Warning Devices B. Training and Procedures

Task 2

Factsheet Reading Method for Task 2.

The Small Group Activity Method places workers at the center of the learning experience. It is designed to draw on two bodies of knowledge: 1) the knowledge and experiences workers bring into the room and 2) the factsheets contained in your workbooks.

The factsheet method, described below, builds upon this knowledge through the introduction of new ideas and concepts. The process is as follows:

First, select a new scribe for this task.

Each of you will be assigned a small number of factsheets to read. You will then share this new information with your table. The idea is for each of you to take ownership and responsibility for the information contained in your factsheets and to describe it to the others in your group.

Your trainer will assign your individual factsheets in the following way: Starting with the scribe and moving to the left, count out loud from 9 to 16. Keep going around the table until all numbers (factsheets) are distributed. For example, if there are four people at your table, the scribe will have self-assigned Factsheets 9 and 13; the person to their left will be responsible for Factsheets 10 and 14, etc. The numbers that you have assigned yourself correspond to Factsheets 9 through 16 on the following pages.

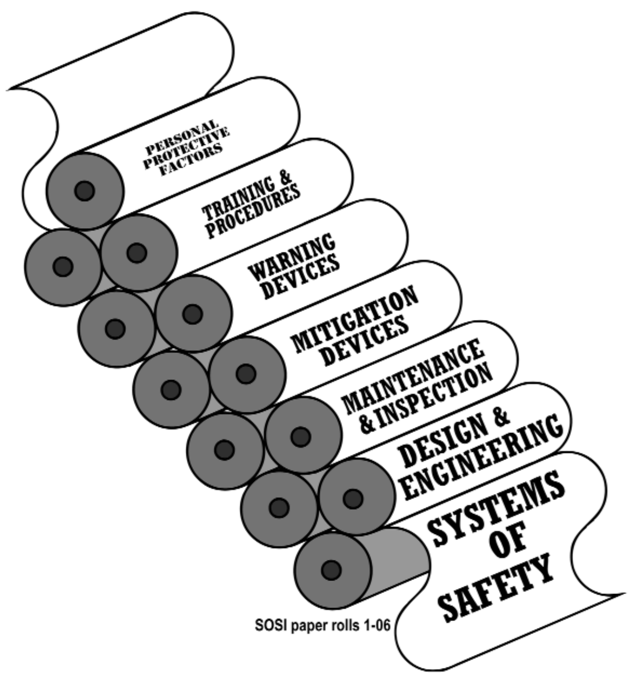
Once everyone has read their assigned factsheets individually, your scribe will go around the table and ask each of you to explain to the rest of your group what you have learned. No notes need to be taken during this discussion. The factsheets should be explained in the order they were assigned (9 through 16), as many times factsheets build on previous factsheets. Once this process is complete, your trainer will read the scenario and the task. In this way we all start at the same place and with the same information.

9. What Are Systems of Safety?

Most facilities should have a developed program called Systems of Safety. This program outlines, in detail, how the plant will operate safely. This is a proactive program designed to prevent disasters and injuries from occurring.

The following components play key roles in eliminating or reducing hazardous conditions at the plant:

- Design and Engineering;
- Maintenance and Inspection;
- Mitigation Devices;
- Warning Devices;
- Training and Procedures; and
- Personal Protective Factors.



Source: Adapted in part from Harold Roland and Brian Moriarty, S*ystem Safety Engineering and Management*, New York: John Wiley and Sons, 1983, p. 202.

10. Safety Systems and Subsystems (Examples)

Major Safety System	Design & Engineering	Maintenance & Inspection	Mitigation Devices	Warning Devices	Training & Procedures	Personal Protective Factors
Level of Prevention	Highest—the first line of defense		Middle—the second line of defense			Lowest—the last line of defense
Effectiveness	**Most Effective**					**Least Effective**
Goal	*To eliminate hazards*		*To further minimize and control hazards*			*To protect when higher level systems fail*
EXAMPLES OF SAFETY SUB-SYSTEMS**	**Technical** Design and Engineering of Equipment, Processes and Software Management of Change (MOC)** Chemical Selection and Substitution Safe Siting Work Environment HF **Organizational *(must address a root cause)*** Staffing HF Skills and Qualifications HF Management of Personnel Change (MOPC) Work Organization and Scheduling HF Workload Allocation of Resources Buddy System Codes, Standards, and Policies**	Inspection and Testing Maintenance Quality Control Turnarounds and Overhauls Mechanical Integrity	Enclosures, Barriers Dikes and Containment Relief and Check Valves Shutdown and Isolation Devices Fire and Chemical Suppression Devices Machine Guarding	Monitors Process Alarms Facility Alarms Community Alarms Emergency Notification Systems	Operating Manuals and Procedures Process Safety Information Process, Job and Other Types of Hazard Assessment and Analysis Permit Programs Emergency Preparedness and Response Training Refresher Training Information Resources Communications Investigations and Lessons Learned Maintenance Procedures Pre-Startup Safety Review	Personal Decision-making and Actions HF Personal Protective Equipment and Devices HF Stop Work Authority

HF - Indicates that this subsystem is often included in a category called **Human Factors**.
* There may be additional subsystems that are not included in this chart. Also, in the workplace many subsystems are interrelated. It may not always be clear that an issue belongs to one subsystem rather than another.
** The Codes, Standards and Policies and Management of Change subsystems listed here are related to Design and Engineering. These subsystems may also be relevant to other systems; for example, Mitigation Devices. When these subsystems relate to systems other than Design and Engineering, they should be considered as part of those other system, not Design and Engineering.

Revised October 2006

See Definitions of examples on next pages.

11. The Design and Engineering System—Two Sides for Safety

The highest level of hazard prevention is gained by using the Design and Engineering System, with each side of this system affecting health and safety.

The Organizational side involves how work is organized and the roles people play. This involves issues such as:

- Staffing levels;
- How resources are used; and
- How work is assigned and coordinated.

The **Technical side** involves the machinery and processes of work. This includes factors such as:

- Process and equipment design and engineering, including redesign;
- Selection of machinery, chemicals and other materials;
- Ergonomic design of equipment and control panels;
- Reducing the inventory of hazardous materials; and
- Choice of less toxic, reactive and flammable chemicals.

Examples of Design and Engineering at home:

- Magnetic latches on refrigerators that prevent children from being trapped inside; and
- The switch-over to latex-based paints reduced lead exposure.

If hazards are to be eliminated, the organizational and the technical sides of workplace design and engineering must be improved to the greatest extent possible. Industry either designs and engineers hazards into the workplace or designs the workplace so that it is healthy and safe.

Source: Nicholas Ashford, "The Encouragement of Technological Change for Preventing Chemical Accidents," Environmental Protection Agency, 1993.

12. The Maintenance and Inspection System

Properly designed equipment can turn into unsafe junk if it isn't properly maintained, inspected and repaired. If the phrase "if it ain't broke, don't fix it" is used within a plant, the maintenance system is a failure. If you don't use preventive maintenance, then you end up doing breakdown maintenance. For example:

At home:

- Preventive maintenance (checking air in tires);
- Inspection (checking tires for wear);
- Predictive maintenance (replacing worn tires); and
- Breakdown maintenance (changing a flat tire).

In industry:

- Preventive and predictive maintenance programs;
- Work repair requests are completed in a timely fashion;
- Keeping spare parts readily available;
- Equipment inspections for wear and damage;
- Maintenance workers are properly trained;
- Much needed repair work not delayed for production requirements; and
- Vibration monitoring and records kept on critical machinery.

13. The Mitigation System

The Mitigation System of Safety involves the use of equipment that automatically acts to control or reduce the harmful consequences of hazardous incidents. Mitigation should be automatic and reliable.

Typical examples of mitigation devices are:

At home:

- Seat belts;
- Air bags;
- Circuit breakers; and
- Pressure relief on water heater.

In industry:

- Relief valves;
- Automatic shutdown devices;
- Check valves;
- Dikes; and
- Machine guarding.

14. The Warning System

The Warning System of Safety includes the use of devices that warn of a dangerous or potentially dangerous situation. These devices require a person's intervention to control or mitigate the hazardous situation.

Examples of warning devices include:

At home:

- Smoke alarm;
- High temperature or low oil light on an automobile; and
- Weather alerts and warnings.

In industry:

- Fire, spill and evacuation alarms;
- Control room alarms;
- Emergency shower and worker-in-trouble alarms;
- Fixed continuous monitors and alarms for hazards and toxic releases; and
- Backup alarms on vehicles.

15. The Training and Procedures System

The operation and maintenance of processes that are dangerous require a system of written procedures and training. The greater the hazard, the greater the need for training and procedures.

Elements of an effective training and procedures system include:

At home:

- Procedures for programming a VCR;
- Learning to drive an automobile;
- Cardiopulmonary resuscitation (CPR); and
- Evacuation procedures and drills for fire at home.

In industry:

- Permit programs for hot work, lock and tag, confined space, etc.;
- Emergency response plan and training drills;
- Operator training; and
- Operating procedures.

16. Personal Protective Factors

The Occupational Safety and Health Act guarantees all workers in the United States the right to a workplace free of recognized safety and health hazards. Though we have strived for this goal, we have a long way to go to achieve it.

An outdated view of Workers' Role in Health and Safety:

Holds that workers' primary contribution to health and safety is wearing Personal Protective Equipment and being continually monitored for their behavior.

Personal Protective Equipment and behavior are the primary emphases when workers' roles are focused on compensating for hazards that industry has built into the workplace.

A modern view (the UWUA/ISWE's view) is that workers' primary roles in health and safety are to:

- Look critically at the workplace;
- Work collectively to identify lurking hazards; and
- Then to contribute ideas, experience and know-how to correct system flaws.

When system flaws are corrected using higher-level solutions like Design and Engineering Systems, hazards are either eliminated or greatly reduced.

Task 2 *(continued)*

Purpose Restated: To introduce the concept of Systems of Safety and accident prevention.

Scenario:

Massive explosion killed 11 workers

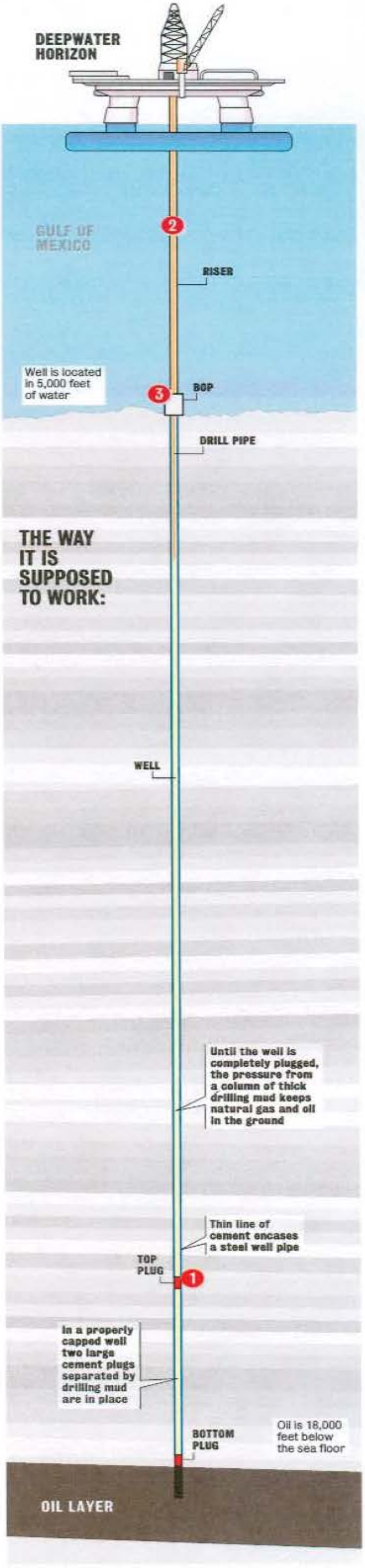
On April 20, 2010, a massive explosion occurred on the Deepwater Horizon drilling rig in the Gulf of Mexico. As a result eleven workers died and a massive oil spill resulted. The fire and explosion was the result of an uncontrolled release of natural gas called a "kick" in industry terms. This happens when the pressure being maintained in the well by the drilling crew is overwhelmed by the pressure of the energy in the oil and gas reservoir being taped into. Process for drilling wells in the deep ocean is very exacting. This was one of the deepest wells ever drilled, over three miles deep, which tested the extent of available technology. And the Deepwater Horizon drilling rig was one of the most sophisticated around. The pressure from the reservoir is controlled by the constant circulation of the mud (chemical composition) designed to remove heat and rock from the drill head as well as provide a counter to the extreme pressure being exerted by the stored energy in the gas and oil reservoir.

The drilling process is fairly straight forward; simply stated a hole is drilled; a pipe is inserted in the hole and cemented into place. The pipe must be straight in the hole and the cement must be formulated for different conditions at different levels of the well or gas will leak in. When the explosion happened the crew was preparing to cap or close the well as they had done their job of reaching the oil and gas reservoir. The drilling platform would then be moved to the next site and a production platform would take over. BP executives had flown out to the rig earlier in the day to praise the crew's safety record. They were also there to discuss scheduling. The deepwater Horizon rig was 43 days behind schedule. These delays cost the company about a million dollars a day and BP managers' bonuses were heavily based on saving money and beating deadlines. There had been 4 previous well control events where fluid and gas came up the side of the "well from hell" (nicknamed by the crew) Exxon had walked away from a similar well project as being too dangerous.

WHAT HAPPENED ON THE DEEPWATER HORIZON

On April 20, Deepwater Horizon was two days away from temporarily capping the oil well it had drilled and handing off the pumping of the oil to a production platform or pipeline. But during this disconnection process the rig suffered a blowout, caught fire and sank to the bottom.

Here is what went wrong:



Note: Vertical height of water and sediment layers is to scale. Rig and drilling components are not.

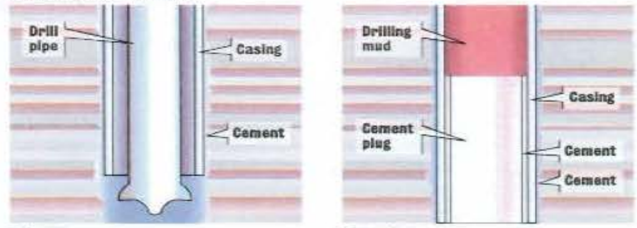
❶ THE CEMENT FAILS

Cement is supposed to protect the outside of the well pipe and is used to seal off a well when needed.

PROBLEM:

Either the primary or secondary cementing failed, pushing a huge column of natural gas into the well pipe.

THE CEMENTING PROCESS:



Primary
Cement is pushed between the well casings and the sediment layers that have been drilled through. It protects the metal wall from gas pressure and from gas leaking up the outside of the well pipe.

Secondary
When a well is to be temporarily abandoned, two plugs are cemented in with drilling fluid between them. Sometimes more plugs are used.

❷ SEAWATER IN THE RISER

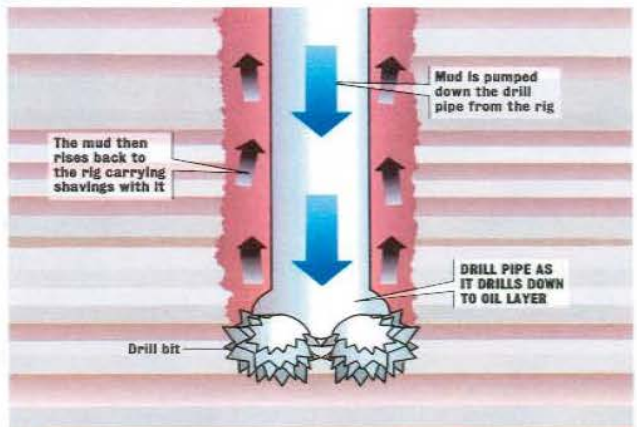
Deepwater Horizon had begun to remove the heavy column of drilling mud that is the primary means of controlling pressure inside a well.

THE USES OF MUD:

- During drilling, mud is pumped down the riser and well to the tip of the drill. The mud then flows back up to rig, taking the drill shavings with it.
- The weight of the mud maintains well pressure so the oil does not rise to the surface.
- The thickness of the mud can be adjusted to deal with a "kick," a sudden surge of gas pressure.

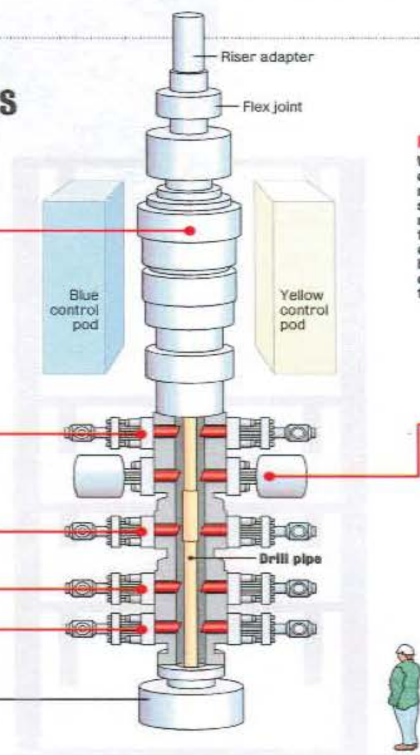
PROBLEM:

When the cement failed, the natural gas rocketed to the surface, as the weakened mixture of mud and seawater did not have the pressure necessary to hold the gas back. The gas exploded the rig, killing 11 men and destroying the rig.



❸ THE BLOWOUT PREVENTER FAILS

The BOP stack is a 450-ton series of valves developed to prevent a gusher if the mud control is overwhelmed.



TWO ANNULAR VALVES: Closes in and seals on the drill pipe. Or if the drill pipe is not in use, it closes the open hole.

FOUR BLIND RAMS: Can withstand more pressure than annular valves over open holes. Not used with a drill pipe in place. Two metal blocks close on each other, sealing the well.

PROBLEM:

With only seconds to react, rig operators fired off the shear ram, but it only partially sheared the drill pipe. A joint may have been in the way, or the ram was fouled by pieces of casing or cement from the blowout. For days, remotely operated robots tried to fire off the ram manually, but failed.

SHEAR RAM: The final fail safe, it is designed to close the well by cutting through and sealing the drill pipe. But they are not designed to cut through joints where two drill pipe sections connect.

Note: Man shown for scale. BOP is located on the sea floor 5,000 feet below the surface.

Source: Staff research

EMMETT MAYER III AND DAN SHEA / THE TIMES-PICAYUNE

Task 2 *(continued)*

Facts

1. The type and volumes of the cement used to secure the casing in the well and to seal potential leaks was inadequate as was the time allowed for the cement to properly cure. There was no testing conducted to determine if the cement had properly bonded in the well despite repeated negative pressure test failures which indicated it might not have set up correctly. Experts on cement composition were told to leave the rig as their services were not needed and they flew off the rig that day.
2. There was lack of operational knowledge on the part of key operating personnel. There were delays in recognizing that hydrocarbons were flowing into the well and riser, and a failure to take timely and aggressive well control actions.
3. Deciding that only six centralizers would be needed to properly align the casing pipes in the well during cementing procedures even though normal operating procedures called for twenty one.
4. There were insufficient checks and balances for decisions involving both the schedule to complete well capping procedures and consideration for well safety. Flaws in operating and safety procedures were not identified or corrected by BP management, BP contractors or the government agency, Minerals Management Services, charged with oversight of these projects.
5. The Blowout Preventer (BOP), which are emergency shutdown mechanisms attached to the well head, were notoriously unreliable. The government regulators had recommended several times over the last several years that a back up to BOP be installed. There was only one BOP installed.
6. The Blowout Preventer had two previous systems failures which were not repaired. A hydraulic fluid leak in one of the rams had not been repaired. And there was a bad solenoid in another one of the rams which had not been replaced. Rams are designed to crimp the well pipe and shut down the flow of oil and gas.

7. The sheer ram on the Blowout protector was not strong enough to cut the drill pipe and stop the flow of gas and oil.
8. Various alarm and safety systems failed to operate as intended affecting the time available for personnel to evacuate. Some of the alarms that detected gas on the rig had been purposely disabled because they were nuisance alarms.

continued

Source: National Academy of Engineering and National Research Council Interim report on causes of the Deepwater Horizon Oil Rig Blowout ands Ways to prevent Such Events, November 17, 2010 and others to be added.

Task 2 *(continued)*

Task:

1. Based on what you have read in the factsheets and your own knowledge, in your groups identify the flaw for each paragraph and list it below. Then circle the system of safety that the flaw occurred in. Please be sure to pick a scribe at each table to record your responses. You can list only one System of Safety and flaw for each paragraph.

Flaws	SOS Targeted
1.	A. Maintenance & Inspection B. Training & Procedures C. Mitigation Devices
2.	A. Mitigation Devices B. Training & Procedures C. Design & Engineering
3.	A. Training & Procedures B. Design & Engineering C. Maintenance & Inspection
4.	A. Training & Procedures B. Design & Engineering C. Maintenance & Inspection
5.	A. Design & Engineering B. Mitigation Devices C. Training & Procedures.
6.	A. Design & Engineering B. Maintenance & Inspection C. Mitigation Devices
7.	A. Design & Engineering B. Mitigation Devices C. Maintenance & Inspection
8.	A. Design & Engineering B. Warning Devices C. Maintenance & Inspection

THIS PAGE INTENTIONALLY LEFT BLANK

Summary: Systems of Safety

1. Proactive Systems of Safety are the key to preventing disasters and injuries.
2. Major Systems of Safety include:
    - Design and Engineering;
    - Maintenance and Inspection;
    - Mitigation Devices;
    - Warning Devices;
    - Training and Procedures; and
    - Personal Protective Factors.
3. The Design and Engineering System can provide primary prevention by eliminating the possibility of a serious accident. The other Systems of Safety provide secondary prevention by reducing the probability or severity of an accident.
4. Each plant may have different structures and names for its Systems of Safety, but all plants have Systems of Safety.

EVALUATION

1. How important is this Activity for workers? Please circle one number.

2. Which factsheets are the most important to distribute to the workers? (Please list the page numbers.)

3. What would you suggest be done to improve this Activity?

____

____

____

____

____