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A View of What We Do--Making Process Safety Second Nature

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Introduction

During the last decade many World-Class Chemical Plants have focused on a mission with at least four distinct elements. These elements include: providing continuous customer satisfaction; striving not to get anyone hurt; striving to fully protect the environment; and being a low-cost producer. In the early 1990's, numerous organizations struggled to incorporate all the requirements of the U.S. Occupational Safety and Health (OSHA) Process Safety Management (PSM) Standard. The PSM standard required a quantum leap in well-developed procedures and readily available documented information. While increased protection of the worker was the focus of the PSM standard, enhanced preservation of the environment was a bonus and for the far-sighted companies who effectively complied, the bottom line is now better supported.

The rewards are now in sight for those corporations who accepted the challenge by using these performance-based standards to provide expensive resources judiciously to correct past oversights and provide a system to keep information current. Good access to key information is paramount in any well-run organization. Many locations developed or improved extensive electronic data bases to cope with PSM requirements.

Today, a chemical plant's decision process can be enhanced by all the readily available information required by the OSHA PSM Standard. Updated P&ID's, comprehensive Process Hazard Analysis details, and the well-documented Operating Procedures can help with training and many decisions. The substantial efforts to provide a stronger Mechanical Integrity program should reduce the risks of major leaks and extend the interval between shutdowns. An effective and rigorous use of Management of Change system should help keep information current.

This paper will review public perceptions of safety in the chemical plant workplace. By using Bureau of Labor Statistics, comparisons will be made between the degree of safety experienced while working in a chemical plant to the degree of safety in some better understood occupations such as fishers, timber cutters, truck drivers, construction laborers and others trying to make a living. Next, in the heart of this presentation, we will review many of the layers of process safety protection that world-class chemical plants utilize to be pro-active in protecting people, property and profit. Most of the images will be of plant equipment and plant workers on the job within a chemical plant landscape. (The strength of this presentation is the 65 + vivid photos, that support the text.)

Concluding sentences will suggest that an operation supported by multiple layers of effective protection can also provide increased security for the employees, the public and increased profits. And finally, there will be a few words to persuade key members of the audience to develop a program similar to the "heart" of this presentation to help convince each company's employees and their citizen neighbors that Chemical Process Safety is "Second Nature". Certain industrial facilities will need vivid word and supporting action images of their operations to overcome the expected public relations' challenge when the EPA required "Worst-Case Scenarios" are released to the public.

Perceptions of Dangerous Jobs

You might be surprised who has the most dangerous jobs. They are not the employees who first come to mind. The U.S. Bureau of Labor Statistics provides an interesting insight to the safety of workers. The Census of Fatal Occupational Injuries administered by the Bureau of Labor Statistics (BLS) in conjunction with participating state agencies, compiles comprehensive and timely information on fatal work injuries occurring in the United States.

Guy Toscano an economist in the Office of Safety, Health and Working, Bureau of Labor Statistics provided an easy-to-understand, thought-provoking article entitled "Dangerous Jobs." (Reference 1) His article is based upon 1995 statistics.

Quoting from Mr. Toscano, "There are a number of ways to identify hazardous occupations. And depending on the method used, different occupations are identified as most hazardous. One method counts the number of job-related fatalities in a given occupation or other group of workers. This generates a fatality frequency count for the employment group, which safety and health professionals often use to indicate the magnitude of the safety and health problem. For example, truck drivers have the largest number of fatalities and accounted for about 12 percent of all the job-related fatalities in 1995. But this number is influenced not only by the risk workers face in that occupation, but also by the total number of workers in the occupation." (Reference 1)

"The second method, fatality rates, takes into account the differing total numbers among occupations. It is calculated by dividing the number of job-related fatalities for a group of workers during a given period by the average number of workers during that period. This rate depicts a worker's risk of incurring a fatal work injury within the employment group and is expressed as the number of fatalities per a standard measure. For example, the fatality rate for truck drivers is 26.2 deaths per 100,000 workers. When occupations are ranked by fatality rates, truck drivers become the ninth most dangerous occupation."

But the easiest method to understand is Mr. Toscano’s relative risk method. He states, "Another method of expressing risk is an index of relative risk. This measure is calculated for a group of workers as the ratio of the rate for that group to the rate for all workers. The index of relative risk compares the fatality risk of a group of workers with all workers. For example, the relative risk for truck drivers in Table 1 is 5.3 which means that they are roughly five times as likely to have a fatal work injury as the average worker."

It turns out that occupations such as: fishers, timber cutters, small plane pilots, structural metal workers and taxicab drivers have the highest relative risks. See Table 1.

Page Break

to Accomodate Table 1

Table 1

Guy Toscano’s Relative Risks

For Fatal Occupational Injuries for 1995

Using Bureau of Labor Statistics Data

Occupation Leading Fatal Event Index

(percentage in brackets)

All Occupations 1.0

Farm Occupations Vehicular (50%) 5.1

Truck Drivers Highway crashes (68%) 5.3

Electric Power Installers Electrocutions (60%) 5.7

Roofers Falls (75%) 5.9

Construction Laborers Vehicular (28%) Falls (27) 8.1

Taxicab Drivers Homocide (70 %) 9.5

Structural Metal Workers Falls (66%) 13.1

Airplane Pilots Airplane Crashes (98%) 19.9

Timber Cutters Struck by Object (81%) 20.6

Fishers Drowning (81 %) 21.3

Just How Dangerous is it to Work in a U.S. Chemical Plant?

Mr. Guy Toscano also provided some 1995 relative risk fatality statistics to help compare several industries relative risk with the occupations described above in his "*Dangerous Jobs*" article. These numbers are specific to 1995, and only involve fatalities.

When you consider truck drivers as an occupation you see statistics focusing only on truck drivers, a relatively dangerous occupation. When you consider trucking as an industry the risk numbers are diluted since the employees of that industry include not only the drivers (a dangerous job) but also the clerical, sales, dispatching, repair and other support groups which have significantly lower exposures.

Having said all of that, Mr. Toscano provided the following. The Chemical and Allied Products classification (SIC Code 28) experienced 38 deaths in 1995 out of a reported 1,289,000 employees. This is a relative risk of 0.6. This is lower than relative risk of the average job. The

1995 statistics for the Petroleum Refining classification (SIC Code 291) experienced 13 fatalities out of a listed 151,000 employees. The relative risk is 1.8.

Contrast these relative risk numbers to the Trucking and Warehousing classification (SIC 42) of 4.1 and the relatively safe Finance, Insurance and Real Estate group which was 0.4. See Table 2.

Table 2

1995 Relative Risks of Fatal Accidents in the Work Place

Using A Relative Risk Index

Fishers (as an occupation) 21.3

Timbercutters (as an occupation) 20.6

Taxicab Drivers (as an occupation) 9.5

Trucking and Warehousing Industry 4.1

Petroleum Refining 1.8

Average Job 1.0

Chemical & Allied Products 0.6

Finance, Insurance & Real Estate 0.4

The typical man on the street in southwestern Louisiana (a region which is rich in fishing, timber, rice farming and petroleum refineries & chemical plants, as well as anti-industry news reporters and attorneys) would be puzzled with the facts. Over the years the media has shepherded the average person into believing that the chemical industry is a very dangerous industry. This is partially enforced by a very few isolated disastrous world-wide incidents and the associated painful suffering. Now let us look at the "Layers of Protection" that are incorporated into the typical world-class chemical facility.

Chemical Plants Layers of Protection

Well-designed chemical plants, petro-chemical plants and refineries have many interrelated layers of protection. Many of the seasoned chemical plant employees and perhaps most of the citizens in the surrounding communities are not aware of the extent of the proactive protective hardware and rigid procedures that good chemical plants have had in place for years.

The layers of protection are sort of like layers on an onion. Each layer is important, but one thickness can entirely hide another. Not all layers are distinct and not all layers totally cover the entire potential risk, but together the sum total of layers offers a thick blanket of protection. It is arbitrary how an individual may chose to separate these overlays of security, but this paper chose Design, Backup Protective Designs, Operations & Maintenance. (The strength of this presentation is the 65 + vivid photos, that support the text, not the text itself.)

Design Considerations Focusing on Layers of Protection

All of a plant's technical staff understand that the chemical design teams rely on seasoned engineers. It is one of the fundamental layers of protection. Seasoned engineers depend on generally recognized good engineering practices, numerous consensus codes, standards and regulations. The list of supporting codes is long. The top ten most referenced sets of standards and publications would include those developed by the American Institute of Chemical Engineers, the American Society of Mechanical Engineers, the American Petroleum Institute, the Instrument Society of America, the National Association of Corrosion Engineers, National Electric Code, the National Fire Protection Association, the U.S. Department of Transportation, the U.S. Environmental Protection Agency and the U.S. Occupational Safety and Health Administration standards. Other process safety reference resources for a plant are provided by the plant's corporate engineering procedures or standards, corporate fire protection guidelines, property insurance organizations, various trade associations (i.e. the Chlorine Institute, the National Petroleum Refining Association, the Vibration Institute, and similar specialty groups) and state & local regulations.

During initial design location, location, and location are important and can be another fundamental layer of protection. The importance of proper location can not be overstressed. Insurance guidelines, fire code regulations often address the spatial arrangements including distances between flammable storage tanks, the distances between process and storage areas and to fence lines or control rooms. During this time, the design team must decide if the inherent hazards and the distances from a potential flammable vapor cloud justify the use of a more costly explosion resistant control room. Included in the design aspects are other considerations to withstand: the internal and external pressure, the temperatures, the chemical exposures, the forces of nature including earthquakes, hurricanes.

It is not good enough to just provide proper equipment design information. The company must ensure the equipment meets specification by providing inspections of critical equipment during fabrication, when it arrives at the plant site and during equipment installation.

Good plant facilities can only be constructed with the use of hardworking, skilled craftsmen, supervised by dedicated, technically-sound contractors and oversight reviews involving the owner/operator field engineering crews. Another essential layer of protection is achieved after the equipment and piping are in place and all of the prestart-up testing and inspection are successfully completed.

The design must include state-of-the-art process indication and control. References such as: the Instrument Society of America's ISA - S84, *Application of Safety Instrumented Systems for the Process Industries* should be consulted for designing the proper system of sensors, logic solves and final control elements in safety instrumented systems.

Additional Design Safeguards for Avoiding Catastrophic Troubles

World-Class plants have provided secondary containment (or diking) for selected flammable storage tank areas for years. Now such organizations are going much further in providing secondary containment for tanks, that handle environmentally unfriendly material. Double wall piping is sometimes considered for highly hazardous fluids.

In today's world, the engineering design teams spend a great deal extra effort on the detail design and control systems for safety systems which provide upset tolerant emergency scrubbing, incineration and standby flare capacity. There is also more design emphasis on systems which provide the early detection of leaks of flammable, toxic, or carcinogen materials. More and more well-designed facilities engineer and locate vapor or gas detectors near pump seals and other potential accidental leak sources as well as on the fence lines at the boundaries of our facilities.

In chemical plants that manufacture and store large inventories of flammable liquids units and flammable gases the active protective system of choice most often involves fire water. The tried and true fire water systems include deluge systems, water curtains or hydroshields and long-range water cannons. Fire water deluge systems are often engineered to provide more than 0.25 gal/min/ft2 which is an engineering term that can be visualized in intensity as ferocious thundershowers of over 24 inches of rain an hour. Such fire protection systems must be designed and maintained to meet fire insurance requirements including reliable diesel pumps and a large volume of dedicated water supply. Important structural steel columns, beams, tank supports and distillation column skirts should be evaluated for possible supplemental fire protection provided via fire proof coatings.

Strategically located, properly instrumented and well-maintained remote-operated Emergency Isolation Valves can limit the consequences of unexpected failures of piping and equipment.

Before a project's costs are estimated the project should be reviewed by a group of process safety specialists who may wish to recommend a Process Hazards Analysis using the team approach.

Operational Considerations Focusing on Layers of Protection

Most major chemical manufacturing facilities operate around the clock, 365 days a year. Very often the evening, night and week-end crews are mainly chemical process operators making product with support from shift supervisors, shift safety and security employees.

The total security of a chemical plant partially rests within the operations functions. This security is much more than the physical security of keeping the wrong kind of people out of the plant. It is the complex process of attracting, properly training, empowering, and keeping the right people in the organization. It is the hiring of motivated workers and community-minded professional technical people who can work as a team. But it also requires leadership in management to provide challenges to make the plant safer, more environmentally friendly and competitive with the competition.

Another distinct layer of protection is the security of providing effective training of employees in classroom settings and on the job. Good training is supported by effective procedures which reflect the unit needs. The training is more than the operation and maintenance of the unit , but also includes compliance with health and personnel safety rules. In today's world, security also includes the periodically federally-required random drug testing.

The use of committees is another chemical plant cultural approach, that may be hard to explain unless you work in industry. The concept of multi-disciplined committees is an effective method to encourage various safety interests and compliance. I am familiar with an umbrella coverage structure of a Plant Safety Council with a number of smaller committees whose focus is on specific areas of safety. There are smaller committees focused on distinct areas, such as: the Emergency Response Planning Committee, the Joint Union/Management Safety Committee, the Process Safety Management Steering Committee, the Electrical Safety Committee, the Off-the-Job Safety Committee, the Behavior-Based Accident Prevention Committee and similar committees. Team audits can also be effective in highlighting certain specific areas of safety.

The operation of a plant includes the professional services from the control laboratory. Such laboratory work includes the testing of the raw materials, intermediates and finished products, as well as, special tests which may be on discharge water and ambient air to comply with permits or for personnel monitoring.

Another layer of protection is provided when operations is fully prepared for an emergency. There must be an effective plan and trained individuals to help with this plan. The plan must have the vital communications to warn surrounding areas of potential problems. Those individuals who store large quantities of flammables and toxics should have access to rough guidelines or real-time dispersion models to predict the dispersion and consequences of an accidental release.

Naturally the responders must be well trained and properly equipped to handle conceivable accidents. Often the responders are sent to fire fighting schools to train on "live" fires. The emergency response planning coordinators must also be periodically trained and refreshed in their training for an event they hope never occurs.

A good emergency plan requires excellent communication from the detection of the release to the projection and migration of the release. Good communications includes timely notification to local agencies to the news media.

Maintenance Considerations Focusing on Layers of Protection

Periodic and breakdown maintenance procedures and practices are another very important part of the Process Safety Management package. Periodic inspections and tests are an essential layer of protection.

Rigorous programs are in effect to ensure that safety relief valves are tested with a frequency that provides reliable overpressure protection. Other specialists routinely (often on a monthly basis) inspect rotating equipment to detect signs of wear or deterioration.

Some of the more universal standard equipment inspections are external vessel and piping inspections supported by thickness measurements taken at places where metal loss is anticipated. During periodic scheduled outages the pressure vessels and storage tanks are opened and inspected internally. No amount of external inspection can be as good as an internal inspection when pitting or localized corrosion is a possibility.

Cross-country underground pipelines are patrolled for signs of changes above ground and checked for proper cathodic protection systems. The cathodic protection inspections are not enough. Many companies rely on pipeline right-of-way pilot/inspectors, who survey the area from above in small planes to detect signs of mechanical threats from nearby construction activities or to spot leaks that may have developed from internal or external corrosion.

Infrared Thermography is a non-invasive Predictive/Preventive maintenance inspection tool that is now beginning to be used extensively throughout industry. It is a proven technology and it is being regularly used on detecting hot spots on electrical distribution systems. By utilizing thermal imaging systems, it is possible to detect and display thermal temperature differences from infrared radiation (heat) emitted by an object. Creative individuals are finding other opportunities to use thermography such as checking furnace tubes for signs of coking. Infrared technology and inspections of this type provide early warning and documentation of impending failures.

Maintenance program managers now understand the needs: for certified welders, welding procedures accepted by codes and certified metal inspectors. Such managers are insisting on properly inspecting and periodically proof-testing instruments that detect leaks, out-of-range values, impending hazards and provide emergency shutdown functions. These instruments must respond when required to warn and to safeguard the process.

Summary of Employees Providing Layers of Protection

World-Class Plants have placed the OSHA Process Safety Management Activities into the hands of the right people with the right motivation and the correct training. These include the intelligent, energetic supervisors, the enthusiastic, motivated chemical process operators, the hardworking, competent craftsmen, the well-trained specialists, and the other team players behind the scenes including the clerical and administrative employees.

Can You Really See the Dollars Saved?

While the costs of a good Process Safety Management Program are objective and easy to quantify, the benefits are subjective and difficult to quantify. I sincerely believe many engineers working in years past, who have struggled with problem solving and learned that documentation was incomplete or scattered throughout a plant, appreciate the new PSM Approach. Furthermore, these same engineers realize there are substantial savings to be reaped by having up-to-date information available on demand.

Ian Sutton in his new book, Process Safety Management (1997), provides a paragraph entitled "Economic Payoff" under the section on Process Hazards Analysis which offers an insight of trying to measure the savings. (Reference 2). His paragraph reads:

> "Although the normal reason for carrying out a PHA is to improve safety, many companies feel that these analyses provide an economic payback. Unfortunately, such feelings are hard to verify. The problems with trying to determine economic payoff are those associated with all kinds of risk-benefit analysis. If the team identifies a high consequence hazard that has never actually occurred, and then recommends spending money to make its probability much lower, there is no direct financial benefit to the company. It is very difficult to justify spending funds protecting against what has never actually happened."

Ray Brandes (formerly Director of Manufacturing and Director of Safety for ICI Americas, and now with SAIC) provided an insight into the value of HAZOPs while he was at ICI. Manpower and preparation costs were noticeable in the manufacturing budget. He satisfied his concern over the cost of doing HAZOPs with a brief study there in 1982.

For four HAZOP studies, he arranged for a senior manufacturing superintendent as a participant. That person recorded his rough estimates of the value of operability findings from the study. The potential return on the studies ranged from 5 to 80 times the cost of the HAZOP, including preparation costs. Ray added, however, that ICI used HAZOP for operability as a matter of practice, beginning in the 1970s.

Pat Berwanger, (Principal Engineer with Berwanger - Oil, Gas & Petrochemical Consulting) recently shared a tidbit about savings due to better documentation of Process Safety Information. He recalled incidents in which natural gas handling facilities had to dig up manifolds of underground distribution piping each time there was a proposed change to the system. The approach prior to the PSM standards was cavalier as the operators just did not bother with developing and maintaining good drawings of the underground systems. So each time someone new wanted to know the details of the underground piping arrangements, the interested party had to search for a backhoe instead of a stick file containing up-to-date drawings. Berwanger knew there was considerable savings in just that simple act of better documentation.

I also recall a plant that had sophisticated and complex compressor and condenser systems that had evolved over 30 years of expansions and growth. Just as in Berwanger's experience, this unit did not rely on keeping the drawings (P & IDs) up-to-date. In this case, the operating general forman would redraw (via a crude hand-penciled sketch) the circulation system and its controls any time there were troubleshooting needs or a need to know. In retrospect, it would have been so much easier and less time-consuming to request professional drafters to develop reproducible engineering drawings with all of the details.

The Mechanical Integrity element of the PSM Standard has been troublesome for a number of industries. Mechanical Integrity is a resource-intensive part of the standard. To address this element properly requires input from a wide range of engineering and inspection disciplines and covers many activities. All the associated activities that are aimed at preventing catastrophic leaks can also reduce the nuisance shutdowns and extend the interval between turnarounds and total shutdowns. Precise or even approximate measurement of an economic payback suffers all the uncertainty that Ian Sutton discussed a few paragraphs ago.

Despite the measurement uncertainties of return on investment, most plant managers understand that using Process Safety Management concepts is GOOD BUSINESS. Those of us closer to the programs and procedures believe there is a very positive payback in peace of mind with PSM. We believe with PSM, we continue to move forward using well-defined, logical approaches to: improve the protection of our employees, improve our environment performance and extend the life of our facilities. With those elements under better control, increased profitablity can be achieved.

Sharing a View of What We Do

The public is often skeptical of what happens within the fenceline of a chemical plant. They just have no way of knowing about all of the layers of protection in design, operation and maintenance. I believe each facility should develop an outreach program to discuss the degree of protection and the specific safeguards including supporting images (photos or videos) as I have just shown. This presentation takes considerable time to develop, but it will be of a high value. Such a program describing the "Layers" should be pro-actively used to help convince each company's employees and their citizen neighbors that Chemical Process Safety is "Second Nature" in their facility. Certain industrial facilities will need vivid word and supporting action visuals of their operations to overcome the expected public relations challenge when the EPA required "Worst-Case Scenarios" are released to the public.

Literature Cited

Toscano, Guy A., "Dangerous Jobs" in Fatal Workplace Injuries in 1995: A Collection of Data and Analysis, Report 913, U. S. Department of Labor, Bureau of Labor Statistics, April 1997, Washington, D.C., pp. 38 - 41.

Sutton, Ian S., Process Safety Management, 2nd ed. Southwestern Books, 1997, Houston, p.151.

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