Hazard Communication

Technology Safety Data Sheets

Moving critical safety information upstream to design engineers and downstream to workers

By Magdy Akladios and Gary Winn

Abstract: *New technologies and processes can pose risks to users, much like those caused by exposure to chemicals. As part of the right-to-know concept, a standardized resource such as technology safety data sheets (TSDS) can provide workers with the adequate knowledge to protect themselves from those risks. This article describes TSDS and discusses how these tools can be used to educate managers, designers, engineers and other potential users on basic aspects of safety and health.*

CHEMICAL HAZARDS and methods to relate those hazards to workers, managers and designers have challenged SH&E professionals for many years. Incidents such as the catastrophe at Union Carbide's facility in Bhopal, India, led to a strong push for what is now known as the right-to-know movement (EPA, 2006). It also prompted several regulations, such as OSHA's Hazard Communication (HazCom) standard (29 CFR 1910.1200). Under this standard, OSHA mandates that all users of chemicals should maintain what are now called material safety data sheets (MSDS). Produced by chemical manufacturers, MSDS provide information such as manufacturer name and contacts, hazardous ingredients, physical data, fire and explosion hazard data, health hazard data, reactivity (instability) data, spill or leak procedures, special protection information and special precautions (ANSI, 1998).

Like chemicals, man/machine interactions have become more complex because of technological advances. This complexity increases the level of risk to which workers are exposed. As a result, identifying and assessing associated hazards has increased in complexity as well. To better manage these concerns, information sheets simulating MSDS for chemicals were introduced (McCabe & Lippy, 2001).

Called technology safety data sheets (TSDS), these documents aim to capture and relate a concise abstract of technical information in a user-friendly format. TSDS use information gathered through hazard analysis techniques such as job safety analysis (JSA) or failure modes and effects analysis (FMEA). Much as MSDS provide chemical hazard information to different audiences in one format, TSDS are communication tools to be used by various audiences.

According to Department of Energy (DOE) and National Institute for Environmental Health Sciences (NIEHS) (1996), a TSDS is a "technology-specific document designed to provide, among other information, the identity and relative risk of safety and health hazards associated with a technology. It can be used as a tool to manage safety throughout the technology development and implementation process, and it can provide developers with a method to collect and report hazard information in a form understood by the user community."

History & Origination

TSDS was originally developed in 1994 by Matthew Fitzgerald while working under a contract for the DOE. In 1995, DOE entered into a cooperative agreement with the International Union of Operating Engineers (IUOE) to begin addressing worker safety and health considerations related to environmental technology research, development and demonstration programs (McCabe & Lippy, 2001).

In 2000, DOE's Environmental Management Advisory Board (EMAB) recommended that a TSDS be provided for every technology at mid-stage review (EMAB, 2000). DOE then began to pilot test TSDS as a way to provide guidance on avoiding potential hazards in individual technologies (McCabe & Lippy, 2001). Although it was later reported that mid-stage review was too early for full TSDS development, it was concluded that "it is never too early for a technology developer to start considering safety and health in the research and development process" (McCabe & Lippy, 2001).

TSDS Format

Currently no regulatory mandate is in place for a TSDS to be developed or for the format to be used if one is developed. However, published guidelines suggest that the following elements be included: technology identity, process

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description, process diagram or photograph, contaminants and the medium, associated safety hazards, associated health hazards, phase analysis, safety and health plan required elements, comments and special considerations, and case studies (DOE & NIEHS, 1996).

The initial format compiled the elements outlined in OSHA's Process Safety Management (PSM) standard (29 CFR 1910.119) and presented them in a manner that could be used by employees who operate and maintain the technology, SH&E professionals charged with protecting personnel on hazardous waste sites and regulators who must write permits for technologies on state Superfund sites (Lippy, 2003). The initial format focused on processes themselves, and on the ways operators and maintenance personnel interacted with these processes. Depending on the complexities involved, an appropriate hazard analysis technique was selected (e.g., what-if/checklist, hazard and operability study, FMEA, fault tree analysis).

Theoretically, the original format contained information accumulated throughout the entire process of development, demonstration and deployment of a technology. In its Policy for Occupational Safety and Health in Sciences and Technology Programs, DOE requires the use of TSDS, starting at appropriate points in the engineering development phase for maximum benefit (IUOE, 2002).

A second-generation format has emerged in the past 5 years. In this format, developers focus on worker issues such as behavior and willingness to take risks. Hence, hazard analysis techniques that focused on process safety no longer fit their objectives. Since JSAs focus more on tasks performed by

Table 1

Comparing PSM & TSDS Elements

Element	PSM	TSDS
Gather and display technology's information	•Information pertaining to the dangers of the highly hazardous chemicals used or produced by the process. •Information pertaining to the technology in the process (diagrams that will help users understand the process, and maintain it under control). •Information pertaining to the equipment such as condition's design must be documented (ASME, API, ANSI, NFPA codes).	•Technology identity; •process description; •process diagrams. These sections provide key technical information to people in order to understand the technology as is required by the standard.
Hazard analysis	Based on this information, PSM will perform a PHA or safety analysis. Depending on the complexities of the process, an appropriate technique will be selected. Options include: what-if/checklist; HAZOP; FMEA; FTA.	•Safety hazards; •health hazards; •system safety analysis; •phase analysis. No decision is made on the use of any hazard analysis technique. Section 7 in the first version of TSDS describes the results of a hazard analysis, but it does not determine how to do it. The lastest protocols eliminate the section and stipulate the use of these techniques to determine an appropriate assessment of the hazards. Another important point refers to the format used by TSDS. It describes the results obtained in the hazards analysis by separating the hazards descriptions in to safety hazards, health hazards, phase analysis hazards and emergency conditions. Each topic constitutes a section.
Operating procedures	PSM standard requires development and implementation of written operating procedures that provide clear instructions for safely conducting activities involved in each covered process. Steps for each operating phase are initial startup; normal, temporary and emergency operations; normal shutdown; and startup following a turnaround or after emergency shutdown.	•Safety and health plan; •emergency condition information; •special considerations. TSDS also present a specific section, namely phase analysis, to describe the hazards involved in each life cycle phase of the technology. This concept can help developers incorporate safety aspects into designs or to final users to address hazards during the use and deployment stage in the technology.

a person and how well a procedure is executed, they are a more viable alternative. Therefore, process safety has given way to occupational safety in the effort to produce an effective communication tool.

Sutton (2003) suggests that occupational safety and process safety are both part of an overall system safety, but asserts that they are separate and distinct. He also suggests a relationship between system safety, occupational safety and process safety:

> Indeed, during the follow-up to serious process-related accidents, it is often observed that the facility in question had a good occupational safety record, which is one reason senior managers are often so stunned after a major incident—their good occupational safety record had led them to believe that all was well. For these reasons, the line from occupational safety to process safety is not solid, indicating a weak link. On the other hand, a facility with a good process safety program probably will do well at occupational safety, so that line is solid, indicating a stronger link (Sutton, 2003).

Since worker safety is the ultimate goal, the second-generation TSDS format illustrates and communicates safety and health information to workers and combines both approaches into one source (Table 1).

Process Safety Management

The major objective of PSM is to prevent or mitigate the release of hazardous chemicals likely to cause serious accidents. To achieve this, PSM has three stages: identification, evaluation, and mitigation or prevention of chemical releases that could occur as a result of failures in process, procedures or equipment. To control such hazards, workers must develop the necessary expertise, experience, judgment and initiative to properly implement and maintain an effective PSM that includes gathering and displaying information, identifying and assessing hazards, and writing operating and training procedures (OSHA, 1994).

Three main sources of information are required to implement a PSM:

- information on the hazards of the highly hazardous chemicals used or produced by the process;
- information on the technology in the process (e.g., diagrams that will help users understand the process and maintain it under control);
- information about equipment conditions (e.g., pressure and temperature limits).

Based on this information, PSM uses a tool called process hazard analysis (PHA). Depending on the complexity of the process, an appropriate technique such as what-if/checklist, hazard and operability analysis (HAZOP), failure modes and effects analysis (FMEA) or fault tree analysis (FTA) is selected. Finally, the PSM standard requires development and implementation of written operating procedures that provide clear instructions for safely conducting activities involved in each covered process.

The TSDS format compiles these PSM phases and expands their application beyond preventing or mitigating the release of hazardous chemicals to use with other types of work-related hazards. The TSDS presents hazards in a clear, comprehensible format, making it an important document for communicating hazards in any type of industry.

Hazards are best controlled before they are created. However, if a designed system goes to market, worker behavior can be modified to avoid accidents. Therefore, a TSDS may be used with designers and/or workers and safety managers in mind.

Proposed New Format

The lack of a standardized procedure and format has prompted the proposal of a unified approach. TSDS take advantage of hazard analysis techniques (or safety analysis methods). This systematic approach enables developers to analyze diverse objects, ranging from simple machine components to complex production processes. It also addresses ways in which operators and maintenance personnel interact with these processes. Thus, the first step in developing a TSDS is to recognize the nature of the object being analyzed. This will help to determine the approach and hazard analysis method to be used during the development of a TSDS.

Operation Analysis

Grimaldi (1975) defined the fundamentals of operation analysis as follows:

1) Break down the job or operation into its elementary steps.

2) List them in their proper order.

3) Examine them critically.

The operation analysis technique investigates the steps of a job to identify and eliminate those that are inefficient. SH&E professionals examine each step for its accident-causing potential. Four units—dubbed the 4 Ms—should be considered when analyzing a job operation for its possible hazards:

- man: all persons related to the job;
- method: working procedures;
- machine: simple tools to complex systems;
- material: includes substances and items other than machines.

Heinrich, Petersen and Roos (1980) explain how a production system should be divided into units to facilitate the identification of hazards. The same concept is presented by Harms-Ringdahl (2002) when describing a modern production system where the simple machine has been replaced by a production system. In this context, a production system "can be seen as a number of elements that must interact for a desired result" (Harms-Ringdahl, 2002).

The main components of a production system include technical equipment and physical conditions; individuals within the company; organization and activities; surroundings, including society.

Table 2

Hazard Analysis Techniques

Technique	Applications	Pros	Cons
Technical (T)		*Can give "strict" results*	*Human/organization missed*
Energy analysis	All types of systems	Simple method, quick, gives an overview.	Limited analysis of causes.
HAZOP	Chemical installations	Well known, many manuals, straightforward to use.	Time-consuming.
FMEA	Mechanical and electrotechnical systems; can be widened	Well established, international standard.	Time-consuming. Many possible failures.
FTA	All types of (technical) systems	Well established, international-standard; logical summary of causes of an accident; basis for probabilistic calculations.	Time-consuming and difficult; errors can be concealed; binary (yes or no).
Event tree analysis	All types of (technical) systems	Well established. Provides a clear picture of sequence of events after a failure. Basis for probabilistic calculations.	Rather difficult. Binary (yes or no).
Human (H)	*People's actions in systems*	*Human actions are essential*	*Difficult to model and predict*
Action error method (several similar ones)	Well-defined procedures in process industry, for example	Straightforward use, rather simple.	Focus on normal process. Many possible failures.
a) Hierarchical task analysis	Map out the task of an individual, all types of systems	Goal oriented, well structured description. A basis for further analysis.	Does not support identification of risks (not a real safety analysis method).
System (THO[a])	*Also organization oriented*	*Organizational activities are decisive*	*Difficult to model and predict*
Job safety analysis	Defined work procedure for an individual worker or a team	Simple to learn/apply; similar to traditional safety thinking.	Too traditional, new hazards not found; not suitable in automatic systems.
Deviation analysis	All types of systems	Generic; works on most systems, simple flexible principle.	Sensitive to structuring, many deviations at different levels.
Safety function analysis	All types of systems	Generic; works on most systems; focus on safety, making it right from the beginning.	Rather difficult, results can be presented in different forms.
Change analysis	All types of systems	General; simple principle.	Based on occurred accidents; assumes that the original system is safe enough.
a) Audits (in general)	Check of (safety) management; all types of systems	Essential to check that SM works. With a suitable checklist, it can be rather easy.	Depends much on the checklist; can be an empty formality; difficult to apply on flat organizations.

Note. *From* Safety Analysis Principles and Practice in Occupational Safety, *by L. Harms-Ringdahl, 2002, New York: Taylor & Francis Inc.*

[a]*THO = technical, human and organizational aspects.*

According to Harms-Ringdahl (2002), these four elements constitute a method of separating a job or operation, when analyzed, into simple compounds. Literature related to hazard analysis techniques offers a broad range of names for these techniques. While many of these techniques are similar, they may have different naming conventions due to lack of standardization of safety terminology and communication. The three basic thought processes by which hazards may be identified are:

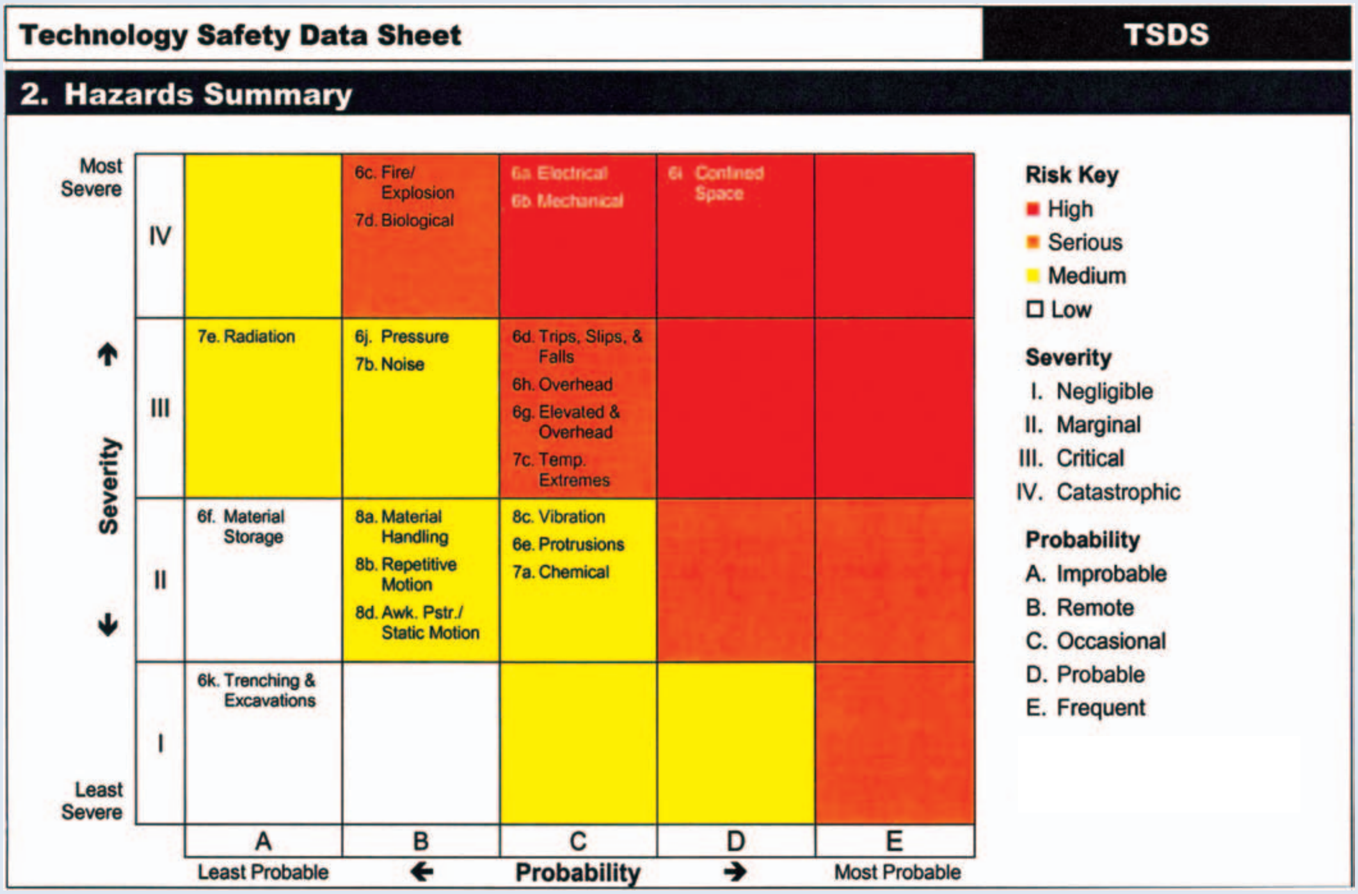
1) deductive: based on a list of undesired events;
2) inductive: based on physical part failure modes;
3) inductive: based on human failure modes.

Developing a TSDS: What Works Best

More than 50 hazard analysis methods are available. Harms-Ringdahl (2002) describes 10 select methods based on the belief that these techniques are simple to apply and suitable for use in the work-

Figure 1

Example 1: TSDS Elements



place. He also proposes a classification of techniques in three groups:

•Technically oriented: moves from specific to general; used to analyze equipment or components.

•Human oriented: for analyzing human errors and task; used to predict human errors in a defined task, and to consider what can go wrong.

•Organization oriented: involve all elements related to organizational activities such as how the work is performed and by whom, safety routines, etc.

Table 2 describes several of these methods, their area of application, and the positive and negative characteristics associated with them.

Approaches for Different Audiences

Hazards are best controlled before they are created—that is, during the design phase of a process, system or technology. Designers can modify engineering aspects to design safe technologies before they go into production. However, if a designed system goes to market, worker behavior can be modified to avoid accidents. Therefore, a TSDS may be used with designers and/or workers and safety managers in mind.

Although the focus of a PHA is process safety issues, it will likely uncover occupational safety concerns and vice versa. TSDS developers must classify their findings and provide the right information to the right audience. This is when the TSDS takes on an important role as a communication tool.

First, workers need to know the hazards to which they are being exposed. Second, workers need to know what protective measures to use to guard against these hazards. TSDS also provide information to designers to help them control hazards via design modifications. Not only is this important for the technology in question, it also provides subtle knowledge and helps educate non-SH&E professionals on the basic aspects of safety and health issues and the different ways to mitigate these risks.

To reach the level of standard communication tool, additional concepts must be described as well. For example, it is critical to clearly describe the technology, process or task (e.g., an entire installation, type of machine, specific machine, part or workplace as a production line or production process, transportation system, specific type of work, organizational routines) in which the engineers, worker or SH&E professional will be involved. Important issues related with this aspect are:

•display of information related to the technology, such as flow process diagram, schemes of different systems, and pictures and diagrams showing the steps to perform a task;

•use of brief operation description to understand the object or task.

A worker's risk perception as a consequence of hazard assessment will help modify his/her behavior. The worker can better visualize how risky a given technology or task is and his/her perception helps the SH&E manager to rank hazards and make appropriate decisions.

Since each organization has a unique way of characterizing the degree of hazard, there is no standard methodology in this area.

Another consideration is the life cycle of the technology and all the different states that can occur from cradle to grave. These safety considerations apply during planning, design, production start, operation and decommissioning. MIL-STD-882B specifies general system designs requirements: Eliminate identified hazards or reduce associated risk through design, including material selections or substitution, and select those with least risk throughout the life cycle of the system when potentially hazardous materials must be used (DOD, 1984).

Selecting the Development Team

According to Harms-Ringdahl (2002), composition of the TSDS development team depends on what is to be studied, not necessarily the knowledge of the hazard analysis methodology. "An important advantage in creating a team lies in the way the analysis can be rooted at company levels. Through a stage-by-stage process of clarification and adjustment, results can become broadly accepted within the company" (Harms-Ringdahl, 2002).

Several problems can arise if just one person conducts the entire analysis (Harms-Ringdahl, 2002). Therefore, a multidisciplinary team must perform the hazard analysis that leads to the preparation of a TSDS; this team should include an expert in the technology under investigation; a potential user(s) of the technology such as a worker(s) with the skills needed to operate the technology; and experts with knowledge of the specific hazard analysis methodology to be used. In addition, if the technology poses a hazard that requires specific knowledge, an expert in that field must be present as part of the team (IUOE, 2002).

TSDS in Practice

One effective approach developed by IUOE (2002) arises from an adaptation of MIL-STD-882D (DOD, 2000). This method considers both probability and severity in a quantitative way. Simply, the standard requires that risk assessment be used in formulating decisions related to resolving identified hazards (Brauer, 1994).

Another approach was developed by the Indiana University of Pennsylvania's National Environmental Education Training Center (IUP-NEETC). This method evaluates probability as the chance of the hazard occurring only when the technology is in operation or under maintenance.

Advantages of TSDS

TSDS provide several advantages:

1) Multiple approaches to hazard identification reveal different hazards.

2) TSDS is the most thorough, comprehensive format of identifying, evaluating and controlling hazards in a single document.

3) TSDS allows a quantitative risk value and hazard rating to be calculated based on risk, which is the multiplication of the probability and severity. This resulting risk rating typically ranges from 0 to 4, with 0 being no hazard and 4 being the highest level of hazard. The latter is where one finds the potential for imminent danger to life or health.

4) TSDS acts as a checklist for designers, engineers, SH&E professionals, workers and other personnel on the different risks associated with the technology.

5) Educates non-SH&E professionals on safety issues.

6) TSDS acts as a legal document that safety measures has been accounted for and addressed.

7) TSDS describes the responsibilities of each person coming into contact of a particular technology.

8) TSDS holds designers and engineers accountable for unsafe designs.

9) TSDS acts as a reference for users of similar technologies to follow.

Figure 2

Example 2: TSDS Elements

3c. Uses	
This section will provide both general and specific information on where the technology or components of the technology are applicable. This would include types of industries and processes where the technology has been used successfully in the past at other sites or facilities.	Additional information that can appear in this section includes : • Benefits and advantages of process/technology. • Why this technology may be chosen over another.

4. Worker Protection Measures	
4a. Engineering Controls	
Engineering modifications represent more permanent controls for protecting workers from safety and health hazards. This section will provide a list of control recommendations that would offer the greatest protection and summarize the recommendations that appear in Sections 6, 7, and 8 of this TSDS document. Examples for Thermal Desorption are provided in the next column:	• Install protective barriers at rear of trailer to protect electrical boxes from impacts and contact with vehicular traffic. • Install safety guards on moving conveyor belt and the soil discharge pipe to prevent caught/pinch hazards and thermal burns. • Install more permanent guide rails around trailer platforms to prevent falls from heights. • Provide wash station for workers to decontaminant when they enter/leave soil treatment area.
4b. Administrative Controls	
Administrative controls represent the second line of defense should engineering controls not be feasible or cost effective. Examples for Thermal Desorption are provided in the next column:	• Rotate employee activities. • Institute a double-check system for verifying procedures. • Ensure workers sign in prior to entering work zone to be briefed on current site activities and things to watch for. • Use spotters for any confined space work. • Take regular breaks when temperatures extremes exist. • Document employee allergy conditions. • Use lift machines when heavy material is involved or repetitive lifting is required.

This technique also has a color-coded numerical rating that indicates the potential severity of injury and/or illness due to existing hazards. An important contribution to the TSDS format is the added visualization of the hazard assessment in an easy-to-understand color matrix.

Figures 1 through 6 provide examples of a TSDS for a thermal desorption technology at McClellan Air Force Base in Sacramento, CA (IUP-NEEC, 2003). This example shows the additions of hazard color-coding, which directs the reader to focus on the most important hazards first. Less-hazardous situations are also summarized, but are given secondary importance. The quantitative risk valuation and hazard rating is calculated based on the following formula:

Risk = Probability of Occurrence x Severity

The five possible probabilities are:

A = Improbable
B = Remote
C = Occasional
D = Probable
E = Frequent

The four possible levels of severity are:

I = Negligible
II = Marginal
III = Critical
IV = Catastrophic

The resulting four possible levels of risk are low (indicated by white), medium (indicated by yellow), serious (indicated by orange) and high (indicated by red).

Conclusion

While no standardized format is currently available to document and communicate technology-related hazards to workers, SH&E professionals, engineers or other personnel involved in the use of a given technology, such documentation is needed. A standardized TSDS can provide a clear description (both verbally and visually) of the technology, process or task in which the worker will be involved; incorporate hazard assessment information; and describe various situations arising throughout a system's life cycle.

When a multidisciplinary team is created to develop a TSDS, the analysis can be rooted at different company levels. Through a stage-by-stage process of clarification and adjustment, results can become broadly accepted within a given company.

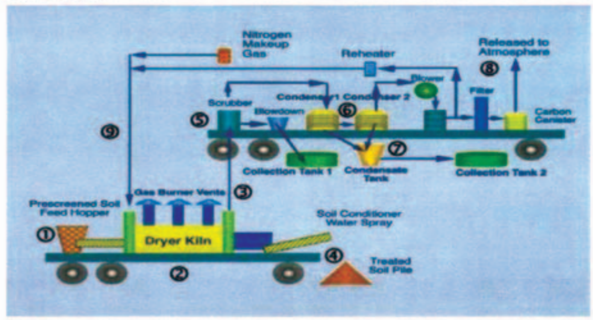
The ultimate goal of a TSDS is to identify key hazards and suggest solutions to mitigate them. As the examples show, TSDS

Figure 3

Example 3: TSDS Elements

3. Technology Description

3a. Process flow diagram



3b. How it works

This thermal desorption system performs low-temperature, ex-situ desorption. The system consists primarily of two trailers. The first holds the dryer kiln and the second houses the gas treatment equipment.

The contaminated soil is not heated above 1000 degrees Fahrenheit, which liberates the organic compounds, but prevents inorganics, metal, and semi-metals from being volatized (freed) with the exception of mercury.

The soil is first fed (1) into a large, rotating dryer kiln (2) that elevates the temperature using an indirect and externally applied heat source (natural gas). Once the soil is "baked" and contaminants are volatized, the liberated organics are directed and carried to the gas treatment trailer using inert nitrogen gas (3). The treated soil from dryer kiln is stockpiled on the treatment pad at the discharge end of trailer (4).

On the gas treatment trailer, the contaminant mixture is introduced first into a wet scrubber (5) that serves to cool the gas, remove dust, and condense some of the organic vapors. Secondly, two condensing units (6) provide additional cooling and condense the remaining contaminant compounds out of the gas stream. The condensate from both condensers is collected in a storage tank for testing (7). The remaining gas stream is treated and then vented into the atmosphere (8) while the nitrogen carrier gas is re-circulated (9).

Figure 4

Example 4: TSDS Elements

4c. PPE

Work Area	Activities	Level of Protection	
All	Site setup, equipment assembly, inspections, site supervision and management, shipping, receiving, sampling, transport, and soil processing.		
Feed soil storage area			
Treated soil staging/storage area			

4d. Safety Program and Worker Training

This section will provide a list of pertinent training and/or certifications that would be required of employees prior to working with the respective technology or process.

This could include employee check-off lists and employee training/orientation for new or transferred workers.

4e. Exposure Monitoring

This section provides industrial hygiene sampling results that may have been gathered along with any noise sampling/surveys conducted.

Brief details on sampling methods used and sampling location and duration will be included under this section.

Recommendations for additional sampling can also be addressed here.

4f. Medical Surveillance

This section will contain any existing records or previous monitoring results that may have been done with this technology at the current location or past applications at other sites.

This section can also contain a list of what allergies or adverse reactions employees may possess when exposed to certain chemicals.

Figure 5

Example 5: TSDS Elements

6i. Confined Space

Probability: (D) Rating
Severity: (IV) Rating

Hazards	Recommended Controls
• During maintenance work requiring entrance into dryer kiln cylinder, engulfment, entrapment, inhalation, and asphyxiation hazards exist for worker.	• Implement confined space program and provide training. • Always use a spotter when one or more workers are inside dryer kiln cylinder. • Monitor air inside cylinder for oxygen deficiency and/or dangerous levels of gas/vapor. • Obtain proper work permits for all worker to be done inside dryer cylinder. • Ensure emergency response teams are available during this time in case they will be needed or called upon.

6j. Pressure

Probability: (B) Remote
Severity: (III) Critical

Hazards	Recommended Controls
• Pressure and burst hazards exist to workers and equipment from piping and related connections between equipment on gas treatment trailer (scrubber, blowdown tank, condensers, blower, reheater, and nitrogen carrier gas system).	• Provide protective guards over piping and/or connections where pressure/burst hazards are likely or are a concern.

6k. Trenching & Excavations

Probability: (A) Improbable
Severity: (I) Negligible

Hazards	Recommended Controls
• None.	• NA

Figure 6

Example 6: TSDS Elements

8. Ergonomic Hazards

8a. Material Handling/Lifting

Probability: (B) Remote
Severity: (II) Marginal

Hazards	Recommended Controls
• During maintenance work requiring frequent movement of tools or equipment up and down access ladders to trailers, the potential for improper lifting and excessive weight loads exists.	• Use of a lift machine or platform can greatly reduce the number of physical trips workers would have to make up and down the dryer and/or treatment trailer(s).

8b. Repetitive Motion

Probability: (B) Remote
Severity: (II) Marginal

Hazards	Recommended Controls
• None.	• N/A.

8c. Vibration

Probability: (C) Occasional
Severity: (II) Marginal

Hazards	Recommended Controls
• Maintenance work performed on motors and/or pumps from condenser, wet scrubber, blowdown tank, blower, and/or reheater units present potential for exposure to vibration to workers' fingers, arms, hands, and legs.	• Return motors, pumps, and equipment to "zero energy" state prior to beginning any maintenance or exploratory work • Use protective gloves designed to help absorb vibration when working on such equipment.

8d. Awkward Posture/Static Motion

Probability: (B) Remote
Severity: (II) Marginal

Hazards	Recommended Controls
• None.	• NA

9. Emergency Measures

9a. Evacuation

Evacuation Map

This section would contain set by step directions and instructions for workers and operators to evacuate all work zone areas in the event of a fire, spill, or explosion. Instructions should evacuate workers to designated safe areas and include direction on accounting for workers and reporting incident(s) to appropriate response groups or individuals.

provides "recommended controls" for each hazard identified. Ultimately, if all these recommendations are followed, the risk chart should be moved from the red zone (high risk) to the white zone (low risk). ■

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