Risk Assessment and Management in a University Laboratory

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Abstract
The system describes the management system used at Institut for Kemiteknik at DTU to perform safety assessments of new experimental set-ups and to ensure, that MSDSs are consulted before a chemical is used, and government required substitution analysis is performed for substances which are carcinogens

Background

In 1996 the government of Denmark introduced legislation, which forced all companies, private as well as public, to establish a system for critically reviewing their workplaces in order to produce better workplaces, which produce fewer work related accidents and illnesses. Prior to this legislation the country had experienced an increase in work related accident and illnesses especially among certain groups, e.g. cleaning staff, hospital workers and road maintenance crews.

In the first half of 1997 the department conducted a review of all workplaces by sending a questionnaire to every employee, including Ph.D.-students. This was management by the department Safety Committee and the Safety Groups associated with the research groups. The structure of the departmental safety organisation is shown in figure 1. Day to day safety issues within a research group is handled by the Safety Group, which consist of one employee and the leader of the research group. Departmental issues are handled by the laboratory manager.

Figure 1. Safety organisation structure feature single line of command from the

AT (Danish equivalent of OSHA)
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University Safety Committee, chair: vice-chancellor (rector)
|
Department Safety Committee, chair: dept. chairman
|

|-------	Aerosol Research Group,	Safety Group:	Leader Assoc. Prof. Hans Livbjerg Safety rep. lab.tech. Bente Beckerslev
|-------	CHEC Research Group,	Safety Group:	Leader Jørn Hansen Safety rep. Thomas Wolfe
|-------	CAPEC Research Group,	Safety Group:	Leader Prof. Sten Bay Jørgensen Safety rep. Ph.D.-student Torben Ravn Andersen
|-------	Danish Polymer Centre,	Safety Group:	Leader Prof. Ole Hassager Safety rep. lab.tech. Kim Chi Szabo
|-------	Membrane Research Group,	Safety Group:	Leader Assoc.prof. Gunnar Jonsson Safety rep. lab.tech. Bente Lundgaard
|-------	SEP Research Group,	Safety Group:	Leader Prof. Erling Stenby Safety rep. lab.tech. Ole Persson
|-------	Common area & teaching laboratories,	Safety Group:	Leader Lab.manager Niels Jensen Safety rep. vacant
|-------	Workshop,	Safety Group:	Leader Shop foreman Ivan Pedersen Safety rep. assistant eng. Henning Koldbech

government level to the safety issues in the individual research groups.

The department and university safety committees are to give advise to the chairperson, who has the legal responsibility for safety, health and environment related issues within his/her organisation.

The department is engaged in experimental work ranging from synthesis of block copolymers over creating of nano particles of alumina alloys to distillation with integrated heat pump, combustion and emission control in unit ranging in size from laboratory bench to large pilot plants, high pressure thermodynamic measurement and CT-scanning of e.g. oil-drilling cores, Egyptian mummies and bones of old kings. Therefore the Safety Committee was quite surprised when the result of the work place evaluation survey showed almost no problems related to experiments and/or chemicals, except for some questionnaires returned by workshop staff. Especially because we in the previous 3 years had experienced a number of near misses without any injury to personnel.

We wondered what industry were doing to ensure the safety of their experiments in their research laboratories and how did they handled chemicals? Conversations with managers of oil research facilities in 1997 and 1998 in both Canada and USA revelled a number of things:

③ No experiments were performed without an independent person reviewing the experimental set-up.
③ The researcher was given an "box" of pressure, temperature, and other parameters, within which he/she was free to perform any desired experiments. Change to the size of the "box" or change to the experimental equipment, except for replacement in kind, required a new review.
③ The approval procedures were reviewed internally on an annual basis and with external auditors every 3 or 5 years.
③ The safety reviews resulted in equipment, which produced better experiments, than before the system was introduced. This was significant in getting people to accept the system.
③ A management of change process was in place with respect to all experimental set-ups.

Based on this information and the safety committee chairman's personal experience observing the uncertainty about several safety key aspects of a new laboratory reactor designed by one of our foreign guest the Safety Committee in the middle of 1998 reached the following decision:

③ HAZOP analysis has to be performed on all experimental set-ups in the department, both new and existing ones.
③ From the beginning of 1999 a HAZOP analysis would be required before the workshop starts building a new set-up.

Initially these analysis were called risk assessment, but we now use the term safety assessment, which some key personal believe to have a more positive tone. One of our industrial collaborators around this time remarked, that among all the topics taught at engineering schools every engineer no independent of discipline and area of work some time in their working life would likely get in contact with the issues covered in the teaching of risk assessment and safety. Our work to date is described in the section "Management of experimental set-ups" after a description of the issue: How do you get people in a university environment to read MSDS?

Management of Chemicals

In early 1997 the government also introduced regulations about the prevention of the risk of cancer from working with compounds and materials. This regulation requires companies to conduct a substitution search before a compound or material with the ability to cause cancer is used and if the material is used to keep records of who has been exposed to it for 40 years. The idea being, that should these person later in their lives contact cancer, then the files could be used to help determine if the illness was work related or not, and hence decide if the person was eligible for workmen compensation benefits. The issue of implications of the existence of such files on a persons ability to obtain life insurance has been raised, but not resolved completely.

The department safety committee based on this in early 1999 decided to implement a procedure aimed at forcing people to read MSDS before buying a chemical. Each safety group was expanded with a person responsible for the approval process surrounding the buying and use of chemicals. A form was developed to help identify the chemicals of concern, i.e. cancerous chemicals which on the MSDS is marked either R40, R45 or R49, see attachment 1. For substances not in these categories the form remains with the safety group. Since government regulations and also information on MSDS may change from time to time we require the form to be processed the first time a chemical is bought within a 12 month period.

The procedure is as follows:

③ Before buying, use or synthesis of a chemical a work place review (APV) must be available based on either the university MSDS database (only in Danish) or one of the publicly available databases, e.g. http://www.msdssearch.com/.

③ If the substance is marked R40, R45 or R49 a substitution review must be conducted and preliminarily approved by the safety group.

③ Final approval is by the department safety committee, which also decides if registration of the persons using the chemicals is needed. Typically registration is needed for substances containing at least 0,1% of a compound marked R45 or R49.

③ The decisions of the department safety committee with respect to registration of persons using R45 or R49 marked chemicals may be appealed to the university department of safety, health and environment.

This procedure was kicked off by a half day course for the persons involved in the fall of 1999. Since that time the department safety committee has not seen any of the forms, hence at the start of the fall semester 2000 a survey will be performed in order to determine if the system is used or there are other reasons why we don't see any forms.

Management of Experiment Set-ups

The need for performing safety assessments of new experimental set-ups came as explained from some of our industrial friends. The event triggering the implementation was the experience our former department chairman and I had on inspecting an experimental fluid bed combustion reactor almost ready for start-up. This set-up relied in our view to much on the alertness of the person conducting the experiment, and further showed that no analysis had been performed of what could go wrong and what to do about it.

In the early fall of 1999 a half-day course was performed to introduce the procedure of safety assessments to our research group leaders, our lab. technicians and our Ph.D.-students. Approximately 15 of potentially more than 75 people attended this course. At the course the reasons for performing the safety assessment was reviewed and several of the reviews, which at that time had been performed was used as case studies. The attendees was given the form shown as attachment 2 and asked to perform a safety assessment of one of their experimental set-ups. Several persons did this, but clearly not all.

The department safety committee only meet once a quarter, and hence a subcommittee was created to take of the reviews between committee meetings and to give a recommendation concerning the review to the committee. This subcommittee consist of the laboratory manager and a laboratory technician. The subcommittee may give a preliminary approval, so the workshop can go ahead and start the construction of the new experimental set-up. The safety assessment form, see attachment 2, has been developed for assist the researchers with providing the necessary information to the subcommittee, but we are not forcing the use of this form. After an identifying section the safety review form consist of:

③ a table on dangers due to temperature and pressure, including an indication of possible exothermic or endothermic reactions.
③ a table on fire and explosion dangers.
③ a table on health dangers, which is supplemented by the relevant MSDSs and if necessary substitution review forms.
③ a table on the set-ups influence on the environment.
③ a verbal description of the set-up including process & instrumentation diagrams and a description of the main risks associated with the experiments.
③ a table analysing deviations from normal operations.

The latter is not a strict HAZOP at this time, but a simple analysis, which allows the researcher to evaluate the influence of events like interruption of utilities like electricity, natural gas, cooling water and compressed air on the experiment. We have due to a near miss a couple of years ago with an interrupted cooling water supply focused on what happens in the set-up, when a utility again is available.

The names of the experimental set-ups for which a safety review has been performed by the end of the summer 2000 is shown in table 1.

No.	Description	Group	Remarks
1	Flame Diffusion Reactor	Aerosol	MSDS of Al- & Zn precursors not available
2	In-ground feed- and products tanks for distillation /heat pump pilot plant	CAPEC	External specialist to assess inside of tanks for corrosion
3	Selective Catalytic Reduction (SCR) reactor	CHEC	
4	Heating Stage Microscope	CHEC	
5	Solid Fuel Pilot Plant	CHEC	Pilot plant scale
6	Flame Diffusion Reactor	CHEC	Lab. bench scale
7	Lab. Fluid Bed Reactor	CHEC	
8	High Temperature Viscometer	CHEC	
9	High Pressure Diffusion Cell	IVC-SEP	1000 bar equipment, manufactured, tested

No.	Description	Group	Remarks
			and installed under government supervision
10	CT-scanner	IVC-SEP	External consultant to advise on ventilation and shielding requirements
11	Elongation rheometer	DPC	
12	Carbon dioxide hydrate synthesis	IVC-SEP	
13	Cross flow nano filtration	Membrane	
14	Flue gas desulfurization	CHEC	
15	Fixed bed straw combustion reactor	CHEC	
16	Paint surface weir simulator	CHEC	

Table 1. Safety assessments performed during the period from January 1999 until July 2000.

The focus of the subcommittee has been unattended operation. In several cases additional alarms and automatic shutdown systems have been added to the experimental set-ups based on the review. Notably absent from table 1 are with one exception synthesis experiments.

We are behind in our original plan, which required a safety assessment of every existing experimental set-up before the end of 1999. One reason for this is that considerable efforts have gone into safety issues around a new experimental hall for high temperature experiments related to research into making our power plants burn alternative fuels and burn both these and conventional ones much cleaner. The goal of performing a safety review before the set-up is build has not been achieved yet in all cases. In fact only in about one third of the cases mentioned in table 1 was the subcommittee involved prior to the start of construction, which is clearly preferable. Changes are much easier to implement at that stage, than just before the experiments are about to start. The early reviews also seem to take place in a more relaxed atmosphere.

Conclusions

A procedure has been implemented to ensure, that MSDS information is consulted prior to use of a chemical and to trigger a substitution review for substances, which are carcinogens, as required by government regulations. The acceptance of this procedure is currently under investigation.

A procedure has been implemented to perform a safety review of all experimental set-ups prior to construction. We currently have succeeded in reviewing all new set-ups prior to start-up, and about one third prior to construction. We still have a backlog of old experimental set-ups for both research and teaching to review, but the procedure of performing a safety review is getting accepted - even among our students involved in their thesis research projects.

References

Most of the relevant references are Danish government regulations, which unfortunately to the best of my knowledge are only available in Danish.

1. Bekendtgørelse om klassificering, emballering, mærkning, salg og opbevaring af kemiske stoffer og produkter, 1993-10-15-B.829.

2. Bekendtgørelse om foranstaltninger til forebyggelse af kræftrisikoen ved arbejde med stoffer og materialer, 1997-02-17-Arbejdstilsynets bekendsgørelse nr. 140.

Attachment 1. Chemical Usage Review Form This form is a supplement to a MSDS and is used at 'first usage' of a chemical or if more than 12 months has elapsed since the chemical has been used within the research group.

Date:			
Safety Group/Research Group:			
Name of material:			
CAS No.:			
Area of usage and limitations (supplement to local MSDS point A)			
Workplace Analysis / Danger and Risk Analysis:			
R-value for the material:			
Work process and precautions during usage: (supplement to local MSDS point C and D) **With what means will the exposure to this chemical be minimized?**			
Substitution Analysis: If the chemical is a carcinogen or a very toxic compound, then the dept. safety committee must approve usage before work commences.			
Reason, that substitution of this material is not possible in this application: (needed for chemicals marked R40, R45, R49 or Tx)			
Employees, who will be exposed to this material:			
Responsible researcher:		Date:	
Safety representative:		Date:	
Research group leader:		Date:	
Dept. safety committee:		Date:	
Registration in personel file:		YES:	NO:

Attachment 2. Risk Assessment Form.

Safety Assessment of Experimental Set-ups for Research and Teaching at Institut for Kemiteknik

						Date:	
Name of experimental set-up:							
Placement - Building:		Room:		Where in room:		Research group:	
Responsible User:				Responsible supervisor:			
Description of experimental set-up (include Process & Instrumentation Diagrams and other Drawings as attachments):							

Dangers due to temperature and pressure

Operating temperature:	Normal:		ÔC	Max.:		ÔC
Operating pressure:	Normal:		kPa (g)	Max.:		kPa (g)
Exothermic reaction:	Yes:		No:			
Endothermic reaction:	Yes:		No::			
Static electricity:	Yes:		No:			

Dangers due to fires and explosions

Are any materials pyroforic?	Yes:		No:	
If yes, which ones:				
Is electrical equipment in class Ex?	Yes:		No:	
Is there a possibility for an exotherm or a detonation:	Yes:		No:	

Dangers to health (include MSDS's and substitution review forms) and environment

Are there any corrosive materials?	Yes:		No:		Gaseous discharge:		kubicmeter/hr to	
Are there any extremely poisonous materials?	Yes:		No:		Liquid discharge:		kubicmeter/hr to	
Are there any carcinogenic materials?	Yes:		No:		Odours?		Noise?	
Are there any radioactive materials?	Yes:		No:		Dusts?			

Short description of the purpose of the experimental set-up,
include process- & instrumentation diagrams (P&ID) and other drawings:

Description of the main risk associated with the set-up:

Analysis of deviations from normal operation

Parameter	Deviation	Influence on operation	Consequences	Actions
Electricity				
Cooling water				
Compressed air				