To Develop a HAZOP Study Teaching Module

Choy, K K H [1] ; Hui, C W [2] ; Porter, J F [3] and McKay, G [4]

[1] kechoy@ust.hk
[2] kehui@ust.hk
[3] kejep@ust.hk
[4] kemckayg@ust.hk
Department of Chemical Engineering,
The Hong Kong University of Science and Technology

ABSTRACT

This paper describes the development of a teaching module for a Hazards and Operability (HAZOP) study, a key safety analysis method for process engineers. Current teaching methods for HAZOP do not provide students with a visual conception of the consequences of making incorrect safety assessments. This new HAZOP model has an interactive animated case-study section to bring reality to the subject and to stimulate student interest and learning capability as regards HAZOP.

Keywords

HAZOP, safety process, guidewords, case study, action report

AIM OF PROJECT

To develop a new HAZOP Teaching Module to identify hazards and operability concerns in process industry plants. The module will be designed to encourage student interest and learning effectiveness by incorporating a number of stimulating and creative interactive case-study examples.

PROJECT DESCRIPTION AND CURRENT TEACHING PROBLEMS

Hazards and Operability (HAZOP) study is an analysis method which identifies and minimizes the hazards of a process and improves its effectiveness. It is currently part of a final year lecture course and forms part of the practical exercises in the Final Year Design Project, but the HAZOP study module will be modified and integrated into a new Industrial Training Unit course.

The challenges of running the HAZOP exercise in the existing course mode are:

- student difficulties in using all information they have acquired in several lecture courses and adapting to this qualitative assessment approach used in

performing HAZOP Studies
- somewhat heavy and dry theory within the HAZOP lectures
- the HAZOP analysis involves time-consuming study and final-year students may miss some key sessions due to job hunting
- the absence of an absolute correct numerical answer to HAZOP is a difficult concept for students to appreciate
- the development of this concept with the students presents difficulties and is time consuming for faculty because the current approach involves developing numerous alternatives

To solve these problems, this project aims to develop a new HAZOP teaching module tailored to undergraduate teaching. In this way, students can work in a multi-disciplinary team in a simulated office context. It also encourages the development of their communication, systematic thinking and problem-solving skills.

TEACHING AND LEARNING PROJECT OBJECTIVES

The main learning objective in terms of the HAZOP study is that by the end of the module students will:
- better understand the basic HAZOP procedure
- have applied the main basic guidewords of NO FLOW, LESS FLOW, MORE FLOW and REVERSE FLOW to a simulated process design

Other key objectives will be to provide students with valuable experience for workplace skills development through:
1. Role-playing meetings
2. Communicating in groups
3. Working in a team
4. Multi-disciplinary activity
5. Working in a simulated ‘Design Office’ environment
6. Systematic thinking, problem solving skills and analysis
7. Very wide-ranging knowledge base applications
8. Evaluation and reflection assessments for the HAZOP Teaching Module

PLAN OF ACTIONS TO SATISFY THE TEACHING AND LEARNING OBJECTIVES

1. Guidelines on ‘role tasks’ will be given.

2. Guidelines on ‘performing well in meetings’ will be included.

3. ‘Team selection’ and ‘good team characteristics’ will be presented in the module.

4. Participants from other subject disciplines will be invited to the HAZOP meetings to make them multi-disciplinary.

5. Time schedules and constraints will be imposed to achieve targets and deadlines typical of Design Office pressure.

6. Examples will be provided in the module to direct the students to think independently and systematically, and solve problems using the interactive simulation examples provided by CELT.

7. An evaluation and reflection assessment process will be carried out by holding a series of meetings with the students who take the HAZOP Teaching Module in Dec04/Jan05.

SCHEDULE OF DELIVERABLES FOR ACTIONS AND RESPONSIBILITIES

The plan of actions was expanded into a specific list of deliverables and a time schedule showing responsibilities for actions.

Period	**Milestones**
Start 01.06.2004	Phase 1 – Course Materials
Weeks 1 – 2	Detailed definition of scope of all project components (2 weeks) – CENG
Weeks 3 – 10	Development of course materials in note and presentation format – including HAZOP study method schematics (8 weeks) – CENG
Weeks 11 – 22	Interactive 2 or 3 demo case studies (12 weeks) – CELT Flow Chart of HAZOP Study Method Animated HAZOP Examples HAZOP Study Minutes Sheet
Weeks 11 – 18	Develop case study example - CENG: Process description [PD] (1 week). Technical specifications (3 weeks). Process flow diagrams [PFD] (2 weeks). Solution (2 weeks).
Week 19	Develop guidewords list (1 week) – CENG
Weeks 20 – 23	Develop prompts for students to use (very innovative but time consuming to prepare) (4 weeks) – CENG
Week 24	Recording the results (1 week) - CENG
Weeks 25 – 26	Report generation - CENG: HAZOP study meeting minutes (0.5 week) HAZOP close out report (0.5 week) Prepare examples of report (1 week)
Week 27	Guidelines for students (1 week) - CENG Team selection Duties of each team member (role play) Rotation of roles Procedural features of each role
Week 28	Performing well in meetings (1 week) - CENG
Week 29	Linking/networking the team members [applications side] (1 week) – CENG
Week 30	Study group meeting [applications side] (1week) - CENG
Dec 04 – Jan 05	Application of HAZOP teaching module in CENG001
Apr 05	Evaluation and reflection assessment of increased student understanding and rate of understanding HAZOP
May 05	Evaluation Report

KEY NOVEL FEATURES

A number of novel features have been proposed to make the module stimulating.

1. Introduce the HAZOP concept through a series of Questions and Answers.
   Some examples are shown in Appendix 1.
2. The development of an attractive and stimulating T&L Interactive Case Study Unit – this will be the focus of the new HAZOP Teaching Module.
   An example of the 'stills' are shown in Appendix 2.
3. A 'Multiple Choice Pre-test' will be designed for the students to pass before they can access the HAZOP Case Study Training module.
4. A multiple-choice answer process will be introduced into the Case Study Unit.
5. A series of prompts will be developed to act as Case Study aids.
   Example: - Definitions of HAZOP Terminology
   Example: - List of Guidewords and Prompt Questions
   A typical list is shown in Appendix 3
   Example: - A List of Drawing Symbols
6. Automatic downloading of the HAZOP Analysis results to complete the HAZOP Actions matrix report.

MAJOR OUTCOMES EXPECTED FROM PROJECT

1. Development of educational software package
2. Experience for students to work in a small team (4-10 people)
3. Experience for students to work in a multi-disciplinary team
4. Experience for students working in a simulated design-office environment

REFERENCES

1. Kletz, Trevor A, (1999), *Hazop and hazan: identifying and assessing process industry hazards,* Philadelphia, PA : Taylor & Francis, 4th Edition.

2. Kletz, Trevor, (1998), *Title Process plants: a handbook for inherently safer design,* Philadelphia, PA : Taylor & Francis.

Appendix 1

Examples of Some of the Key Novel Features

Introduction to HAZOP Using Questions and Answers

1.1 WHAT is a HAZOP?

A HAZard and OPerability study (or HAZOP) is a systematic, critical examination by a team of the engineering and operating intentions of a process to assess the hazard potential of mal-operation or mal-function of individual items of equipment and the consequential effects on the facility as a whole.

1.2 WHY is a HAZOP carried out ?

The reasons for carrying out hazard and operability studies, are:

i. Primarily, **to identify hazards**, and
ii. To a lesser extent, **to resolve these hazards**.

1.3 WHEN is a HAZOP carried out ?

The timing of a hazard and operability study is determined by the objectives of a study, and in turn determines the benefits that may be gained. The outline concept of a process may be examined to highlight any major omissions or significant features. As further detailing is carried out, e.g., when the process design is complete, the full study procedure may best be applied. Operating procedures may be examined and process modifications or changes must be examined to ensure that all eventualities have been considered. Therefore a project may be studied several times in its lifetime.

1.4 HOW are HAZOPs carried out ?

A HAZOP takes 1.5-3 hours per main plant item (still, furnace, reactor, heater, etc.). If the plant is similar to an existing one it will take 1.5 hours per item but if the process is new it may take 3 hours per item.

Meetings are usually restricted to 3 hours, twice per day, 2 or 3 or even 4 days per week, to give the team time to attend to their other duties and because the imagination tires after 3 hours at a stretch.

A preliminary HAZOP may be carried out on the flowsheet before detailed design starts. This will take much less time than the HAZOP of the line diagrams and will identify ‘areas’ of the process of a particular hazardous nature. It provides a more ‘structured’ and ‘systematic’ approach than a preliminary design review – but NOT the detailed analytical data of a true P&ID HAZOP.

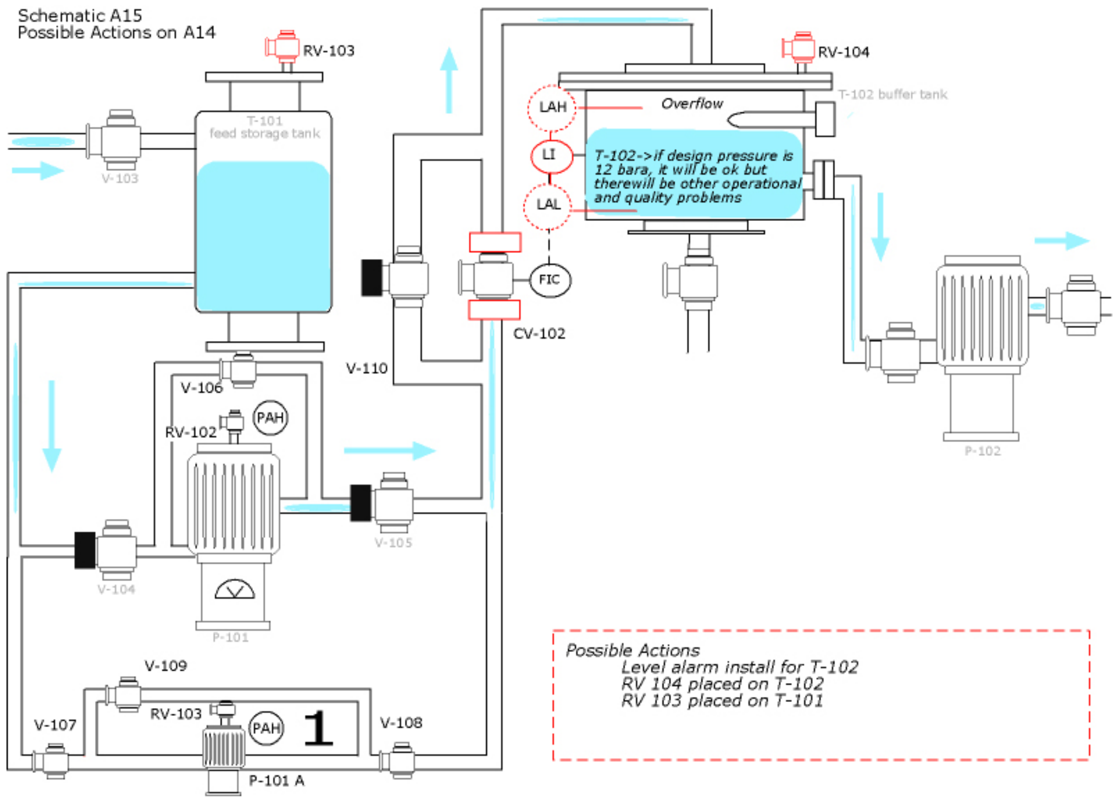
1.5 What information do you need for a HAZOP?

A HAZOP is an examination of engineering and operating intentions. An intention is the expected behavior of a process and its associated hardware, under normal and abnormal conditions. It may be defined either diagrammatically or descriptively; diagrammatically in terms of flowsheets, P&ID's etc., or descriptively, with operating instructions or design specifications.

Appendix 2

Examples of Some of the Key Novel Features

T and L Interactive Case Study



Appendix 3

Examples of Some of the Key Novel Features

Guide Words and Prompts for HAZOP Study

ROOT	PARAMETER	APPLICATION	EXAMPLE
NONE	FLOW	No Flow	Wrong routing, complete blockage, slip plate, incorrectly fitted non-return valves, burst pipe, large leak, equipment failure (control valve or isolation valve, or pump, vessel etc.)
REVERSE		Reverse Flow	As above
MORE OF		More Flow	More than one pump, reduced delivery head, increased suction pressure, static generation under high velocity, pump gland leaks.
LESS OF		Less Flow	Line blockage, filter blockage, fouling in vessels, valves, etc., and restriction of orifice plates.
MORE OF	PRESSURE	More Pressure	Surge problems (line and flange sized) (leakage from any connected higher pressure system, thermal relief.
LESS OF		Less Pressure	Generation of vacuum condition
MORE OF	TEMPERATURE	More Temperature	Higher than normal temperature, fouled cooler tubes, cooling water temp wrong, cooling water failure.
LESS OF		Less Temperature	Line freezing.
MORE OF	VISCOSITY	More viscosity	Incorrect material specification, temperature, etc.
LESS OF		Less viscosity	As above
PART OF	COMPOSITION	Composition Change	Passing isolation valves, double isolations.
MORE THAN		Composition Change	More A added, More B added.
OTHER THAN		(Contamination)	Wrong material, wrong operation, ingress of air, shutdown and start-up conditions.
	OTHERS	Relief	Sizing for two phase
		Instrumentation	Control, flow measurement, pressure relief, instruments, pump overheating due to closed control valves, location of alarms, etc., temp. indicators, flow recorders, etc.
		Sampling	
		Corrosion	
		Service Failure	Cooling water, instrument air, steam, nitrogen, power, etc.
		Maintenance	System drainage, isolation of equipment, preparation for maintenance, shutdown and start-up.
		Static	Plastic lines, solvent velocities, earthing
		Spare Equipment	Critical equipment
		Safety	Lagging, fire fighting, toxic gas, safety showers, security etc.