Part I

HAZARDS STUDIES ON A NEW PROJECT

A template which can be followed during the "Final Year Design Project".

Introduction

Hazard Studies are a "systematic" means of identifying the SHE (**S**afety **H**ealth and **E**nvironment) issues in a project (or even a work plan). They are phased in such a manner that the issues can be identified and resolved in a timely manner without disruption to the development of the "project" be it a major one or a simple plan of work. They are the SHE backbone of all projects and this will include the "Final Year Design Project".

In reality a major project could be as long as 5 years from the concept being raised to the final start-up. As a result the Hazard Studies process may not be obvious but it is being carried out but in the background.

Recap: The main studies are:

0 Inherency
1 Concept
2 **F**ront **E**nd **E**ngineering **D**esign
3 Detailed design
4 Construction
5 Pre-start-up
6 Post start-up (Lessons Learned)
7 Demolition

0 Looks for the "inherently" safer or environmentally desirable features that should be considered at the research stage.
1 Looks at the real show stoppers in the concept. If one is found the project should be cancelled!
2 Looks at the possible problem areas that need to be solved in the detailed design. It also addresses the overall risk assessment.
3 Looks at the finer details and covers a whole series of studies including Pressure Relief, HAZOP and Hazardous Area Classification just to name 3!
4 Asks the question "*Was it built as intended*?" This will involve a section by section assessment of the plant against the construction drawings.
5 Asks "*Is all of the procedures and training in place*?"
6 Asks "*What did we learn that was good and bad*?"
7 Asks "*How do we demolish this safely*?" Some of the questions may result in a change to the design to facilitate demolition.

Clearly 7 could feed back to 3. (If this was done in the nuclear industry the abandonment of the first generation power plants would be much easier (and cheaper).

Timing a design effort

As the detail of the design becomes clearer the cost and number in the design team increases rapidly. For a major project £10,000,000 or more maybe it is only 10 persons in the team at the concept stage but may be 1000 at the detailed design. Clearly the problems MUST be solved before they become a drag on the Project progress and costs incurred due to delays or late project design changes in the project. The Hazard Studies are designed to do just that.

Template: Hazards Studies on a New Project

There is no complete example of the hazard study process available to Academe. This document is an illustrative example of the multi-stage Hazard Study process as applied to a simple a "***synthetic study***" taken from the IChemE booklet "Practical Risk Assessment". It is based on the repair to a chemical sewer which feeds an effluent treatment plant. The sewer receives hot effluent from a number of chemical plants on the site. Some damage in the form of cracked and damaged concrete has been found in the drain at the bottom of a manhole as illustrated in figure 1. The cause of the damage is not clear at present but is likely to be attack from the fluids (chemicals) in the sewer.

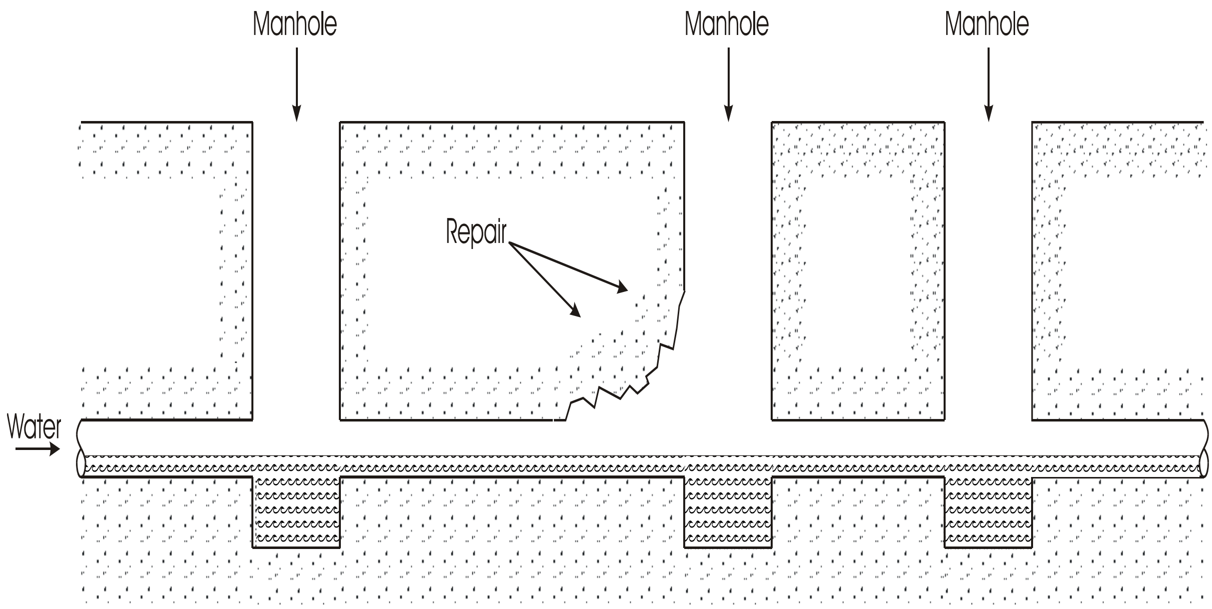

Figure 1 Simplified Sketch of the Sewer to be Repaired

This will use the numbering sequence as shown earlier

Study 0 - Inherency

What is the inherently safer and environmentally friendly solution?

It might be suggested that the "inherently" best solution is to shut the whole site down or to carry out the work during a site "turn around". These can be dismissed as impractical for this study on both timing and urgency for the repair.

Study 1 – Concept

Before we can move into a possible solution it is necessary to know the cause of the damage. How might this be done? If this question is not answered the project can not be developed!

First it will be necessary to inspect the damage in more detail using a remote camera, second it would be desirable to have a sample of the damaged concrete taken by a remotely operated arm for analysis of the damage and original composition of the concrete (was it a poor mix?), Finally it is necessary to have a listing of the materials that enter the sewer and whether there is any possible reaction between an individual compound and the concrete. It is possible that the damage was due only to the temperature of the fluids in the sewer but it is more likely to be due to attack from the chemicals. Damage by thermal effects should also be considered.

After a lot of work in the preliminary studies let us assume that following the chemical survey the problem is identified as attack from the chemicals and it was not a thermal effect. This means that the whole sewer may require replacement over time but the objective now is to keep the site in operation in the short term.

With the constraints imposed the only real solution is to by-pass the damaged section using a pump and to physically isolate the damaged manhole using expandable "plugs or bungs" fitted in the appropriate sides of the upstream and left side of the downstream manholes so as to isolate the damaged section of sewer.

Is the repair to be done remotely or by human contact? Both can be done, modern remotely operated arms are nearly as flexible as humans but for this exercise it is to be assumed that after a lot of consideration human intervention would be more effective than a remotely operated repair this also allows a template to be developed into a usable document.

Is pumping fluids from one manhole to another viable? – It is done many times in pumping out excavations.

There appear to be no real "show stoppers". The concept can now proceed to front end engineering design (FEED).

Study 2 – FEED

What are the risks and how can they be reduced to "as low as is reasonably practicable" (ALARP)?

1. Collapse of the manhole: Does the manhole that is being entered require to be braced (shored up) against collapse? (This is not likely but a full risk assessment by a civil engineer is required.) Solution (if necessary) - design a steel bracing, the materials of construction must be compatible with the fluids in the sewer. This could be done as the chemicals that might attack the steel are

known from the chemical survey in stage 1. It will now be possible to specify the materials of construction.

2. Preventing ingress to the area for repair: Solution - seal the two ends at the upstream and downstream manhole with a remotely fitted bung. Bungs are available but the materials of construction must be compatible with the chemicals in the sewer. Sealing is possible and as the chemicals that might attack the bung have been identified in the chemical survey in stage 1 so it will be possible to specify the materials of construction.
3. Pumping out from one manhole to another: Solution chose a pump. What type of pump should be used? A diesel driven pump or electric motor driven pump? Are there any implications for the hazardous area classification? The chemicals that might be in the sewer were identified in the survey in stage 1 so the materials for construction of the pump can be specified. See also 4 & 5 below.
4. What about the humans? From the chemical survey in stage 1 the likely toxic (and corrosive) materials have been identified. From this it should be possible to specify the PPE. However can we be absolutely sure that there is no other possible source of fume that might enter the manhole while the work is being done? This will initiate another study. Can an emergency exit from the manhole be devised using a harness, lifting frame, "*stand-by-man*" and block and tackle? This is a fairly well practiced means of escape.
5. Finally can some form of chemical resistant "epoxy resin" be identified? What fumes which might be released from the epoxy resin and what are the effects on humans? (Many have a spirit base.) Does this mean that the PPE must include lung (BA) as well as body protection?

OK, it appears that so far there is no real impediment to the concept. The hazards have been identified and practical solutions are available. FEED can now proceed to Detailed Design.

Study 3 - Detailed Design

There are one or two pieces of detail that are required to finalise the design.

1. What is the MAXIMUM and MINIMUM flow in the sewer? Does this influence the controls such as minimum flow of the "pump around" pump or can the pump be operated on "cavitation control"?
2. Are there any special requirements for the pump seal? (The seal may be operating under a negative pressure).
3. What is the vapour pressure (temperature influenced) of the effluent? Does this influence the NPSH of the "pump around" pump?
4. Is an ejector required to "prime" the pump?
5. How is the residual fluid at the bottom of the manhole to be repaired to be removed?
6. What other sources of fume might there be?
7. What is likely duration of the job from start to finish? Does this require a standby pump? Further does this influence the amount of fuel in store if it is not electrically driven?
8. If it is not an electrical pump what are the required fire fighting facilities and also spill recovery if fuel is spilled (drip trays)? (Loss Prevention & Environmental Protection).
9. Will this job involve some limitations to the traffic in the area and what is the impact on the access of emergency services to other parts of the site? What alternative routes may be required? What signage and warning signs are required? What lighting is required both outside and inside the manhole?

There are a whole list of actions flowing from stages 2 & 3. The major ones (as expected, arise in stage 2) and the fine trimmings are in stage 3.

It is now necessary to carry out a few extra studies:

1. HAZOP on the pumping system, including priming, minimum flow and control.
2. Is one pump needed or should there be standby? (Could be part of Study 2).
3. Hazardous Area Classification – this may not be significant but it is a necessary operation. Does this impact on the pump specification and the lighting?
4. Impact on the emergency services rerouting and signage? Who should be informed and when. Should the emergency services be given a site tour to familiarise themselves of the changes? Do the emergency services have any specific requirements? Are there alternative access routes?
5. What area should be closed off to personnel with barriers or tapes defining a "*no entry*" construction site?
6. Are any road closures used for routine access required? Are there alternative access routes?
7. Specify the PPE body protection and breathing air (BA)
8. Define the emergency exit and standby personnel.
9. Define the capacity of fuel storage.
10. What fire fighting and spill control/recovery features are required?

It has been assumed that the job is to be done with human intervention. At the end of this study we can specify:

1. The bung & materials of construction.
2. The pump & control and the materials of construction for piping and the pump itself
3. Hazardous Area Classification.
4. Any new emergency service routing.
5. Any road closures.
6. Roped off areas.
7. The manhole support structure - very unlikely but will depend upon the report/assessment by the civil engineer.
8. Materials for the repair.
9. The escape device.
10. PPE and need for BA (it is more than likely that this will be required). How many air bottles may be required?
11. Fuel requirement, fire fighting & spill control.
12. Lighting.

<u>Study 4 Construction</u>

1. Was it built as intended?
2. Have the emergency procedures been written?

<u>Stage 5 - Ready to go?</u>

1. Have the emergency services been notified of D day?
2. Double check everything is in place and everyone trained in what they are required to do in an emergency.
3. Has the repair team been trained in the use of BA, harness escape, emergency signals?
4. Does the repair team know what has to be done and the scope of their work?
5. Has the PTW been issued? Has this been discussed with the work team?
6. Has the entry permit been issued? Has this been discussed with the work team?

<u>Study 6 - Lessons Learned</u>

1. Even the construction of this note has been educational – there is more to be done than was first thought!
2. The structure of the HAZARD STUDIES was valuable in devising this exercise.

Study 7 Site Restoration (Abandonment)

In this case it is very unlikely that the site restoration will be complex but attention to this phase during the design process would be beneficial.

1. Rubble for a hard standing may need to be disposed.
2. Rubble may require to be cleaned if contaminated with oil/diesel oil.
3. The pump will require to be decontaminated
4. Any equipment/PPE used in the manhole may require to be decontaminated.

If the spill/drip tray is designed properly (stage 3) there should be no need for decontamination of the rubble (2).

It might appear that this analysis might appear to be overly complex (OTT) BUT if the job was to go "*pear shaped*" what would you say to the Judge and Jury? Think about it!!!!

Disclaimer:

This study was devised as a "working exercise" and as a possible template the final year Chemical Engineers Design Project but can not be used in any specific case.