

WALKDOWN HAZARD IDENTIFICATION FOR PROCESS PLANT (WHIPP)

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Walkdown Hazard Identification for Plant and Process (WHIPP) is a hazard identification technique which can be applied to chemical plants, but with modification can be tailored for many industry types. The method adopts a checklist approach to hazard identification which enables auditors and plant operators to carry out plant walkdowns easily and effectively. The information gathered during the walkdown can be used for hazard analysis and quantitative risk assessment.

Key Words: Hazard identification, plant audits, risk assessment

INTRODUCTION

There is an increasing requirement for identification and assessment of chemical process hazards, for example as required by the Control of Industrial Major Accident Hazards (CIMAH) Regulations 1984 and the soon to follow COMAH regulations, the Management of Health and Safety at Work (MHSW) Regulations 1992 or the Offshore Installations (Safety Case) Regulations 1992. In addition to legislative requirements, many companies prepare quantified risk assessments as part of their corporate safety activities and an assessment of the consequences of hazards is often required as an input to emergency plans and identification of likely hazards is necessary before consequence assessment can be carried out.

One form of hazard identification, developed by EQE, is an audit based method known as Walkdown Hazard Identification for Process Plant (WHIPP). As the name suggests, a walkdown hazard identification audit is a visual inspection of a facility to determine potential fault conditions which could lead to accidents.

To facilitate systematic hazard identification and to ensure completeness, a series of guidewords are used as prompts and information collected during the walkdown is entered on specially prepared audit sheets.

For many plant which have been operating for a number of years, it is common to find that the original drawings no longer accurately reflect the current state of the plant, making it difficult to identify faults by use of HAZOP studies alone. In addition, HAZOPs can be time consuming and require the attendance of a number of operating and maintenance staff. However, by carrying out an audit, the safety assessor is looking at the plant as it is currently installed and operated and can quickly identify those areas of plant where HAZOPs would be appropriate.

The WHIPP procedure therefore combines the advantages of a visual plant inspection, that is rapid and reliable information gathering, with the methodical approach of a HAZOP study. Walkdown hazard identification audits can be extremely useful when time is limited and a full HAZOP study is not practical.

This paper discusses the methodology of a walkdown hazard identification audit and gives the guidewords used along with an indication of typical information which should be recorded on the audit sheets.

AUDIT METHOD

The WHIPP audit provides an input to risk assessment, planning etc. as shown in Figure 1. The first stage prior to carrying out the study is to divide the plant into a number of sections. Considering the plant as separate areas is essential if the facility is large or complex. The areas can be determined by location, eg. sections of plant in different buildings could be considered separately, or by function, eg. storage areas could be considered separately from process areas, or by chemical, eg. the use of ammonia could be followed through a process, then sulphur dioxide etc. The major process chemicals used in the plant should be determined in advance, along with some idea of the associated hazards, ie. toxic, flammable, reactive, explosive etc.

For a large site, it may be necessary to carry out the audit over a number of visits, although in all cases it is essential to have a plant operator present during the walkdown, to answer questions as necessary and provide additional information.

When carrying out the audit, the set of guidewords are applied to each section of the plant in turn. The guidewords are intended to promote identification of possible hazards associated with the plant. The guidewords are listed on audit sheets, on which information collected during the walkdown should be entered. As much information as possible should be recorded at the time of the audit and continuation sheets should be used if necessary. If a particular guideword doesn't apply to a section of plant, this should be stated on the audit sheet, to avoid confusion at a later date. The type of information required is discussed in detail below.

As with a HAZOP study, on completion of the audit, the audit sheets should be written up as soon as possible, to avoid mistakes and contradictions.

As Figure 1 shows, the completed audit sheets can then be used to identify potential fault conditions. The method used to identify fault conditions depends on the complexity of the plant, the chemicals involved and their associated hazards. For simple plant with few hazards, compiling a list is all that is necessary. For more complex situations, a risk ranking methodology can be applied, with the consequence and frequency of the hazards qualitatively estimated (ie. severe, high, intermediate, low, negligible for consequences and high, intermediate, low, negligible for frequencies) and the fault scenarios then ranked to identify those which pose the most severe risk.

The completed audit sheets provide detailed information which can be used to assess the consequences, eg. hole size, pressure, bunding etc. and aid the assessment of the frequency of the hazards, eg. frequency of certain types of operation, maintenance, number of certain types of component, protection devices etc. Additional generic reliability data will still be required in most cases to complete the risk assessment. The audit also provides information on the location of workers and the public for the purposes of risk assessment.

AUDIT GUIDEWORDS

The guidewords used during walkdown hazard identification play an important part in identifying potential fault conditions. They also ensure that the audit is systematic and that possible hazards are not overlooked or omitted.

Tables 1, 2, 3 and 4 show examples of the sheets used. Table 1 considers externally initiated events which could lead to hazards, Table 2 is used for internally initiated events, Table 3 is used for collecting information relating to the consequences of the hazard, the principal use of this is for any subsequent consequence modelling and Table 4 is a sheet dedicated to identifying safeguards.

The guidewords for the first two sheets are based on HAZOP 1 guidewords. The guidewords in Table 1 identify a series of external initiating events which could affect the plant or process. The sources of the

events include both those within and external to the site. The second audit sheet identifies a mixture of "top events" and initiating events which could give rise to a significant hazard.

As with HAZOP studies, repetition is possible with these guidewords. For example, incorrect operation may result in overfilling of vessels and high pressure, hence could be recorded under headings 10, 11 and 12 on the Internal Hazards WHIPP Sheet. Where the information is recorded is not important, as long as it is recorded. The guidewords should be interpreted as freely as possible to identify as many hazards as possible. Additionally, if a hazard is identified which appears to fall outside any of the categories on the audit sheets, it should still be recorded. The following descriptions gives an explanation of the information to be collected.

External Hazards

This considers all of the events which are initiated externally to the plant or area under consideration.

Vehicle Impact Lorry/Tanker - Frequency of vehicle deliveries, duration of delivery, distance travelled on site by vehicle, speed restrictions, any barriers, signs or obstacles, any other lorries/tankers not associated with section under consideration which pass close by (including those on public roads).

FLT - Frequency of fork lift truck usage, distance travelled on site, speed restrictions, presence of barriers, obstacles or signs.

Private Vehicles - Frequency of vehicle usage in the area, distance travelled on site, speed restrictions, presence of barriers, signs or obstacles, car parking facilities, any public vehicles which pass close by.

Trains - Any railway lines close by, any speed restrictions etc. Frequency of trains, distance travelled on site (where applicable).

Missiles - are compressed gases used or stored in the area, what are the pressures and quantities involved? Any fast moving machinery, for example pumps, compressors, turbines, motors, centrifuges, stirrers, fans. Any explosive materials stored or used in the area, storage/usage conditions (eg. quantities, type of containment, explosion protection), any unwanted reactions/processes which could cause an explosion if they inadvertently happened (eg. runaway reactions, impurities/contaminants, accumulation of explosive by-products).

Aircraft - Any airports or air bases close by, frequency of flights from airports/bases. Type of aircraft eg. civilian, commercial, military.

Cranes - Any purposes for which cranes or hoists are used routinely, frequency of use, duration of each crane usage, potential for dropped loads to cause a hazard, precautions taken to avoid hazards during crane operations (eg. shut down operation during crane usage). Similarly the use of cranes for maintenance, and the use of portable cranes or hoists. Any new construction on or near the site where mobile cranes or tower cranes may be used which may pose a toppling or swinging load hazard.

Knock-on Effects - Effects of a particular hazard/fault condition on nearby plant or equipment. Can the event escalate? Effect of nearby plant, equipment or operations on the facility (eg. hazardous/flammable chemicals stored nearby, missile generation from nearby plant).

Fire and Explosion - Any flammable/explosive materials stored or used in the area, any potential ignition sources, presence of fire or smoke detectors, sprinklers, fire extinguishers, fire alarm arrangements.

Dropped Items - Items lifted over plant in the area, including items from other areas or facilities (eg. gas cylinders, drums, crates etc., frequency of such movements, special precautions taken. In addition, plant items lifted, raised etc., any sections of the plant raised above ground level (eg. on platforms), potential for dropping items off platforms etc..

Natural Hazards - Is the plant in an exposed area which could be subject to strong winds, is protection against the effects of wind provided. Are there any rivers or water sources nearby which could cause flooding, is the plant area under consideration above or below the water level likely to be achieved in a flood. Is the equipment secured to prevent floatation, are any flood defences provided. What are the effects of earthquake and the consequences of catastrophic failure of plant items, knock-on effects. How is plant/equipment supported and secured? Is the lightning protection adequate, what is the hazard from lightning in this area?

Internal Hazards

This considers any events which are initiated by failures or faults within the plant or area, including human error.

Mechanical Failure (Loss of Containment) - What could influence catastrophic failure including the type of vessel (eg. pressure vessel) or pipeline, length of pipe or dimensions of vessel, likelihood of catastrophic failure, any welds on vessel, materials of construction, potential for extremes in pressure or temperature. What could influence leakage including the number of valves in section of plant under consideration, type and size of valves, are they welded or flanged. Number and size of flanges, number of bolts per flange, gasket width. Type of vessel (eg. pressure vessel), standards to which vessel is constructed, has the vessel been moved or used for a different service. Are connections flanged, welded etc. Are flexible hoses used. Type of welds, number of welds and connections.

Corrosion - Any evidence of internal corrosion, Any evidence of leakage. Are corrosive substances handled? Are the pipe/vessels rated for the chemicals handled? Any evidence of external corrosion.. *Is corrosion hidden by lagging? Do pipes pass through other areas of plant in which corrosion could occur (eg. wet or acidic atmospheres)?*

Incorrect Operation - What are the Effects of opening/closing valve or switching pump on/off at wrong time, effects of operating pump in wrong direction (eg. due to incorrect replacement/wiring of pump after maintenance). What are the effect of failure to carry out maintenance correctly or sufficiently frequently, effect of failure to isolate after maintenance. Are there any other potential for error and resulting hazards depend on operations carried out on process plant.

Overfilling of Vessels - Is it possible? Any alarms present to prevent overfilling. Do vessels have bursting discs? Are there bunds or sumps to contain overflow? Where would overflow go, procedure following overfilling?

High/Low Temperatures and Pressures - Is it possible to get high temperature or pressure in process fluid? Possible causes and effects, precautions and alarms present, knock-on effects. What is the result of cooling of fluids? Can a vacuum be created? Is it possible to isolate pump downstream (ie. create a dead-head)? Could pump create high pressure downstream? Maximum output of pump. Is there a potential for external heating from a fire in the area or from nearby plant which could cause heating of plant/substances in the area under consideration, any heaters or welding equipment used.

Misrouted Fluids - Is it possible to get mis-routed fluids via other lines for example, are water, compressed air, purge gases entering process fluids or vice versa, potential effects (eg. liquid in compressors, gases in pumps, presence of contaminants etc. causing unwanted reactions). Alternatively are Diverters incorrectly set for example potential for failure to spade off a valve, valve incorrectly opened.

Consequences

This considers all issues associated with the consequences of a hazard.

Tank Storage - Maximum, minimum and normal mass/volume of chemical stored, dimensions of vessel/pipework, thickness of vessel/pipe walls.

Flow Rates - Flow rate from vessel/through pipe, frequency of flow from vessel.

Pressures - Maximum, minimum, normal working pressures in pipework/vessel. Can a vacuum occur? Is there pressure relief or alarm? What are alarm settings?

Height above ground - How high above/far below ground is tank/pipework? At what height are pipework connections to vessel?

Bunds - Type and height of bunds, distance from vessel, size of bunded area, include drip trays or trenches for pipelines.

Building /Other Containment - Describe structure of building if applicable (eg. brick, cavity walls, concrete clad steel frame), any leak detectors within building, any ventilation. Does ventilation system shut down on gas detection, fire etc?

Low Points - Any low points, dimensions of maximum pool area, any sumps.

Drains - Size, location of drains. Where do they feed to? Are there interceptors, lagoons, direct discharge to river etc?

Cascades - Potential for cascades (eg. liquid pipelines/vessels above ground level or on grating floors so spillages can fall under gravity).

Flammable Loading - Any flammable liquids/gases present, fuel for vehicles, large amounts of combustible material.

Ignition Sources - For example electrical equipment, welding, static discharge (eg. from release of liquid droplets), sparking (eg. due to impact of objects), personnel (eg. smoking), lightning.

Location of the Public - Distance to housing, roads, fences, level of security to prevent access to site, particular areas where there are large congregations of people or a number of susceptible people (eg. schools, hospitals, sports stadia, old people's homes).

Location of Workers - Is the facility normally manned? Location of nearest personnel, location of control rooms, location of any emergency refuges, presence of any protective equipment (eg. breathing apparatus).

Safeguards

This considers the safeguards in place to prevent or mitigate hazards.

Inspection - How often are inspections carried out and what is looked at during them? Are tests carried out following the making/ braking of connections eg. on a flexible hose connection to a delivery tanker. Are insurance inspections carried out, how often are these conducted and what do they examine?

Maintenance - Frequency of maintenance, what is examined during maintenance, downtime during maintenance, any tests carried out following maintenance.

Isolation - Any isolation valves provided, are they manually/ automatically operated, if manually where is the location of the initiator, what is the isolatable inventory (where applicable), how long does it take for isolation to be achieved?

Non Return Valves - Location of NRVs, equipment isolated by NRV.

Padlocking - Items of equipment that are padlocked, related to PTW?

Emergency Stopbuttons - Location of any emergency stop buttons, which items of equipment do they stop, length of time before equipment stops.

Towaway Connections - Breaking point, amount and phase of chemical that may be lost.

Pressure Relief Valves - Pressure at which they lift, final (relieved) pressure, time to relieve, location to which the valve relieves?

Inerting - Pressure of inerting gas, gas used.

Manangement Systems - Are PTW systems operated, instruction provided for all routine operations and postulated emergency conditions. Training arrangements.

Control and Instrumentation - What is provided, PLC linked, are control panels in control room or adjacent to equipment, trip and alarm set points, where are the alarms located, what form do these alarms take ie. flashing beacons, sounding alarms?

APPLICATIONS OF WHIPP

The WHIPP audit method has been used for a variety of EQE projects. It is most useful for plants with fairly simple to moderately complicated systems; the more complicated a system becomes, the less benefit there is in using this technique rather than a HAZOP study.

One use of WHIPP has been as a screening tool for more complicated plant. A recent project using WHIPP was the application of the audit method to a refinery complex. The WHIPP was used to identify all hazards on storage units, services and some of the units. In addition it was applied to the remaining units, picking up many hazards and recommendations were made for some areas where HAZOP study may be necessary to ensure completeness. This allowed the team to cover the entire plant and focus detailed attention only to the areas requiring it.

Some of the plants for which WHIPP has been used is shown below.

Plants for which WHIPP has been used	
<ul style="list-style-type: none"> • Ammonia store and plant using ammonia in the process • Chlorine store on a chemical works • Water Treatment Works • Ammonia pipeline • Petroleum Storage Tanks (Underground) • LPG Bottling Plant • Speciality Gases production and bottling plant • Petroleum Distribution Terminal • Natural Gas Production Terminal • Town Gas Production Plant • Gas Transmission and Distribution System • Rubber manufacturing plant • Fertilizer Plant • Refinery 	

CONCLUSIONS

Walkdown Hazard Identification for Process Plant is a useful procedure for quickly identifying hazards in process systems. The procedure acts as a data collection exercise, as well as a hazard identification method, thus cutting down on the time taken to complete the risk assessment.

EQE have used the method successfully in a number of projects in the past five years and have refined the audit guideword list over that period. The method can be developed for identifying hazards in systems other than process plant.

Figure 1: The Use of WHIPP in Risk Assessment

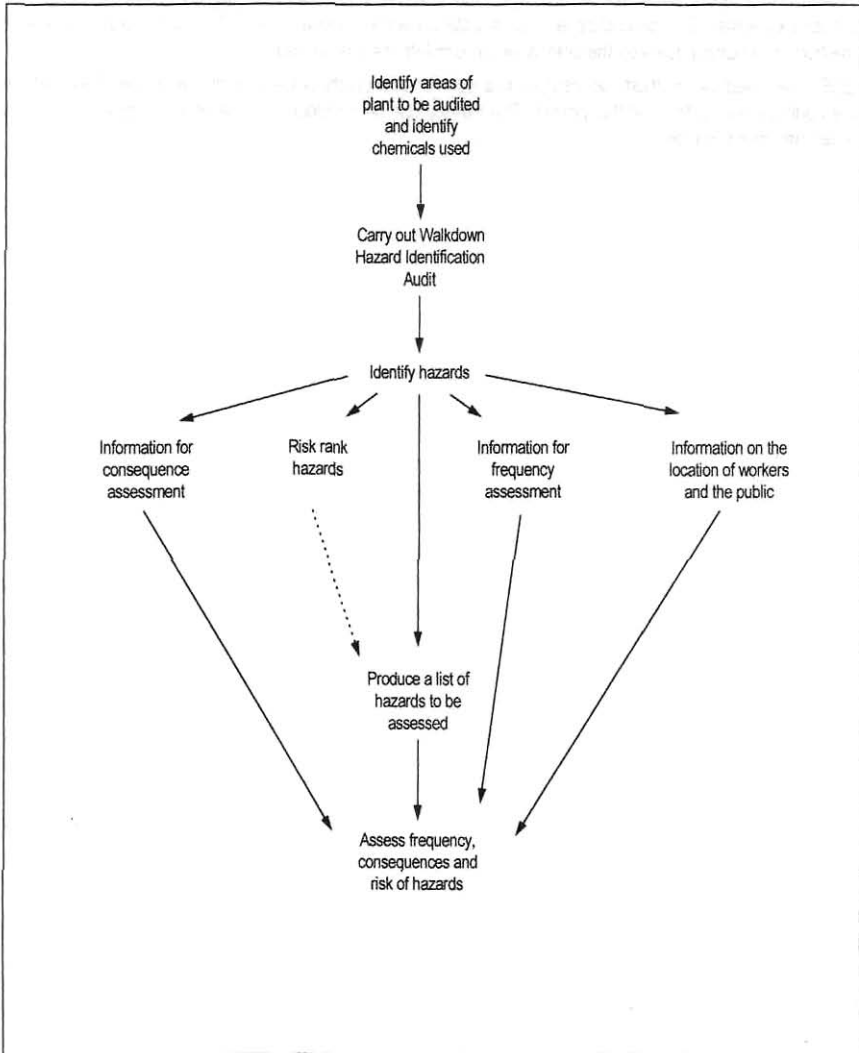


Table 1: External Hazards WHIPP Sheet

EXTERNAL EVENTS	Area:
1. VEHICLE IMPACT	<ul style="list-style-type: none"> - Lorry/Tanker - Private Vehicles - Trains
2. MISSILES	<ul style="list-style-type: none"> - Compressed gases - Fast moving machinery - Explosive processes - Aircraft
3. CRANES	<ul style="list-style-type: none"> - Operational use - Maintenance use - New construction
4. KNOCK-ON EFFECTS	<ul style="list-style-type: none"> - Item on nearby plant - Nearby plant on item
5. FIRE/ EXPLOSION	
6. DROPPED ITEMS	<ul style="list-style-type: none"> - Onto plant - Plant items dropped
7. NATURAL HAZARDS	<ul style="list-style-type: none"> - Flooding - Wind - Earthquakes - Lightning

Table 2: Internal Events WHIPP Sheet

INTERNAL EVENTS	Area:
8 MECHANICAL FAILURE (LOSS OF CONTAINMENT)	<ul style="list-style-type: none"> - Catastrophic - Leakage <ul style="list-style-type: none"> - valves - flanges - vessels - connections - pipewelds
9 CORROSION	<ul style="list-style-type: none"> - Internal - External
10 INCORRECT OPERATION	<ul style="list-style-type: none"> - Valve/pump operation - Maintenance - Other
11 OVERFILLING OF VESSELS	
12 HIGH/LOW TEMP/PRESS.	<ul style="list-style-type: none"> - Process Fluids - Pumps - External heating
13 MISROUTED FLUIDS	<ul style="list-style-type: none"> - Via other lines (services) - Diverters incorrectly set

Table 3: Consequences WHIPP Sheet

CONSEQUENCE	Area:	Chemical:
TANK STORAGE: FLOW RATES: PRESSURES: HEIGHT ABOVE GROUND:		
BUNDS: BUILDING/OTHER CONTAINMENT:		
LOW POINTS: DRAINS:		
CASCADES:		
FLAMMABLE LOADING: IGNITION SOURCES:		
LOCATION OF THE PUBLIC: LOCATION OF THE WORKERS:		

Table 4: Safeguards WHIPP Sheet

SAFEGUARDS	Area:
INSPECTION:	
MAINTENANCE:	
SAFEGUARDS	
ISOLATION:	
NON RETURN VALVES:	
PADLOCKING:	
EMERGENCY STOPBUTTONS:	
TOWAWAY CONNECTIONS:	
PRESSURE RELIEF VALVES:	
INERTING:	
MANAGEMENT SYSTEMS:	
CONTROL AND INSTRUMENTATION:	