Assessing the Risks When Expanding Process Plants or Building New Units on Compact Sites

Eur. Ing. Robert Canaway B.Sc. C.Eng., F.I. Chem.E., M.I. Mar.E.
Managing Director, Suregrove Limited, 20 White Beam way Tadworth Surrey KT20 5DL
suregrove@btinternet.com

Many Energy, Process and Utility Plants are being expanded or new units are being added to sites which often leads to existing facilities being compromised.

This paper will provide some insight into how the plant risk assessment should include a review of the exposures to infrastructure, the original plants, and utilities.

This presentation will show how the risk assessments were carried out on 4 Case Studies and relate these to some well-known accidents which occurred due to layout and design deficiencies.

Key Facts

Expansions or revamps on existing sites are often more complicated projects than new greenfield site development requiring more manhours per piece (of equipment). Particular attention to detail is necessary to integrate the work into an existing site – planning is essential, an accurate scope of work, cost estimate, achievable schedule and sufficient manpower

Competence of the owners' representatives and the appointed contractors is of paramount importance to a successful completion

Working on 'Live Sites' requires careful attention to prevent accidents

Efficient use of the allocated plot area may require layout and design iterations to fit all new facilities and adherence to spacing guidelines in the codes

Execution of too many simultaneous tasks may lead to poor project performance and risk of failure or incident

External project reviews, audits and checks are recommended throughout the project execution

Design of Brownfield Sites

Large energy, chemical, oil, gas, petrochemical, and refineries are rarely designed as a final configuration. There are a variety of reasons for this:

1) The investment profile is insufficient to construct all the plants in one phase and production may be required to provide funds for expansion
2) Sales markets change over time with new demands for different products or increased capacity of existing facilities
3) Environmental Legislation demands emission control is upgraded with improved contaminant removal such as toxic gases, water treatment and waste disposal
4) More efficient modernized units are required to eventually displace older plant, and these have to be built before decommissioning. This might include process, utilities, storage and pipelines

FRONT END ENGINEERING DESIGN (FEED)

Description and PFDs/UFDs
Design Basis and Soils Report
REVISED Plot Plans, Piping and Instrumentation Diagrams, General Arrangements, Isometrics
Equipment List
Structures & Buildings
Schedule and Critical path
Power and Control System Modifications
Interfaces for Piping, Power, HVAC. LOTO
Isolation List – Blinds, Valves, CSO, CSC
Spares (Commissioning and 2-YEARS Operational)

OWNER

CONTRACTOR

1) List of all Inventories in the plant, how they can be isolated Composition, Pressure and Temperature
2) Work Permit System (training of contractors)
3) Process Safety Management Systems
4) Firefighting Requirements
5) Camps, Catering, Transport, ID Card Access
6) Temporary Buildings
7) Training, Disciplinary Procedures
8) Confined Space Entry, System, Isolation, Inerting
9) Minimum Welder Qualification

OWNER

CONTRACTOR

1) Existing Documents Up–to-date? Available electronically and hard copy?
2) Capability of All Relief Systems
3) Utilities Requirements
4) Condition Survey
5) Suitability of Existing support structures for additional weight, increased heat generation (ensure electrical racks are above pipe racks)
6) Vulnerability of plant and expansion to fire/explosion
7) Is current fire protection system adequate? Two firewater supply routes to all areas, any increased demands for fire water or foam?
8) Access routes for maintenance and firefighting are sufficient?
9) Check ease of operation of all manual valves, access to sample points and all field gauges can be read by personnel
10) Is HVAC adequate for new building heat loads?

OWNER

CONTRACTOR

THIRD PARTY

1) Hazard Identification and HAZOP Studies
2) Quantitative Risk Assessment, Safety Case
3) Pre-Start Up Safety Review
4) Punch lists for defective work
5) Positive Material Identification
6) Testing and Commissioning
7) Continuous Clean-up of site
8) Lessons Learned
    a. CLEAR Scope, Contract, Variances Procedure
    b. Cost Estimate sufficient ?
    c. Sufficient Time to execute ?
    d. Assignment of Experienced Qualified Staff
    e. Control System Design - Seamless Team
9) Review Final Options

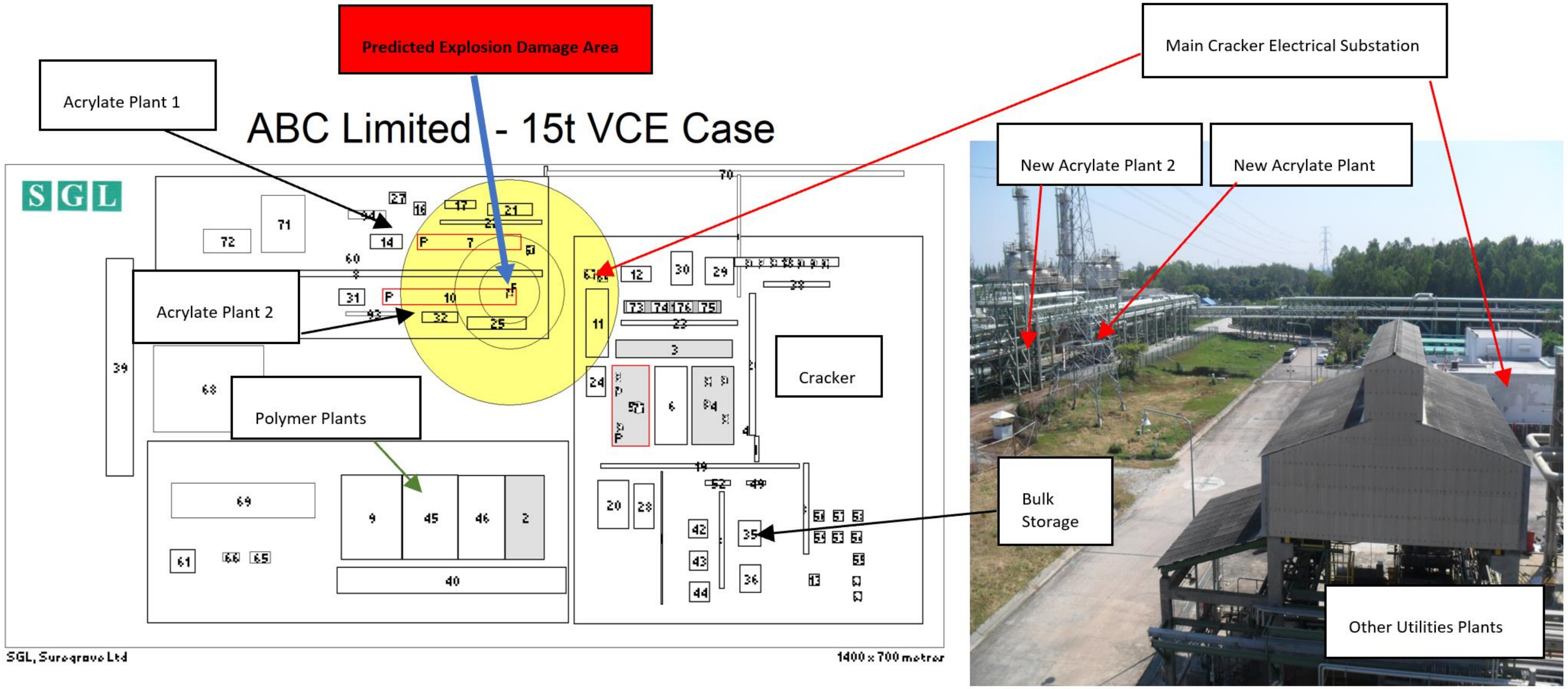
OWNER

CONTRACTOR

1) Process, Mechanical, Electrical, HVAC, Instrumentation Checks/Approvals
2) Operations – Operability Studies, Procedures
3) Maintenance – Accessibility Studies, Procedures
4) Inspection – Materials Selection, PMI, Vendor Works Inspections, NDT, Setting up Data Bases, Trending of Data
5) HSE – Implementation of PSM, Permits, Incident Reporting, Fire Protections, Corrective Measures
6) Security – Theft, Malicious Damage, Worker I.D., Access
7) Human Resources – Recruitment, Training, Behavioural Assessment, Disciplinary Matters
8) Procurement – Long Lead Items, Ordering, Payments
9) Construction – Clearance of Punch Lists, Modifications, Tie-ins, Nozzle Replacement, Weld Heat Treatment, Mechanical Completion, Pressure Testing
10) Testing and Commissioning Team – 72-hour at full capacity rule
11) Problems – Follow the contract, use reliable block valves for appropriate service, verify steel quality, check on corrosion, erosion and worn-out equipment.

Figure 1

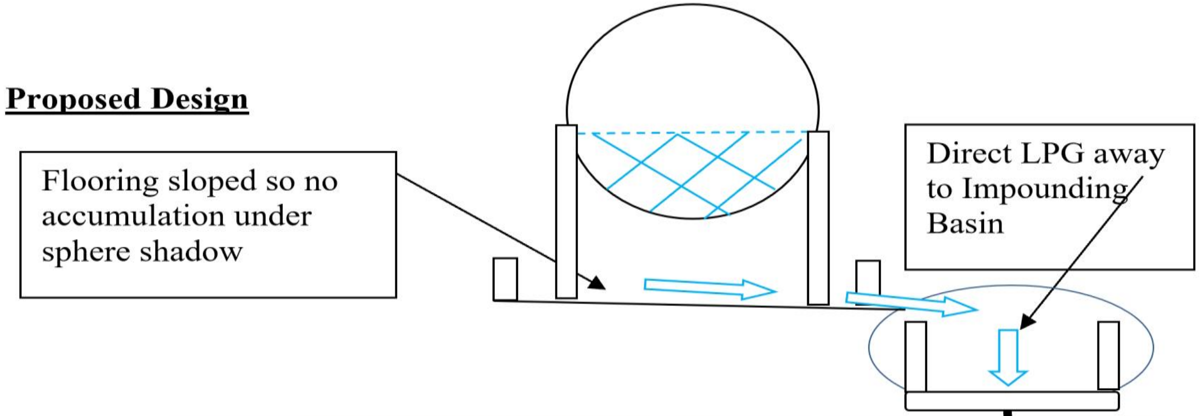
Explosion on
New Plants
Impact Existing
Cracker



This Case Study shows the impact of adding two new downstream units – and the effect of an explosion which could damage peripheral utilities (previously in a safe area). Loss of the main plant substation shutdowns the main cracker and all production). Solution – relocate substation, split the substation, install a bank between the new units and the substation?

Figure 2

Explosion on New Plants Impact Existing Cracker



This Case Study illustrates the impact of spheres located close to the process plant and risk from a BLEVE – leakage should be directed to an open impounding pit via sloped flooring and channels.
Reduce small fittings, all welded piping, automated shut-off valves, improved firewater deluge.

Figure 3
Use of Gas Barrier

This Case Study shows the impact of building a new sour gas compression train. The gas barrier inhibits a sour gas leak from traversing the site towards the new construction area, allowing the workforce to evacuate. Row of gas detectors to warn of a release.

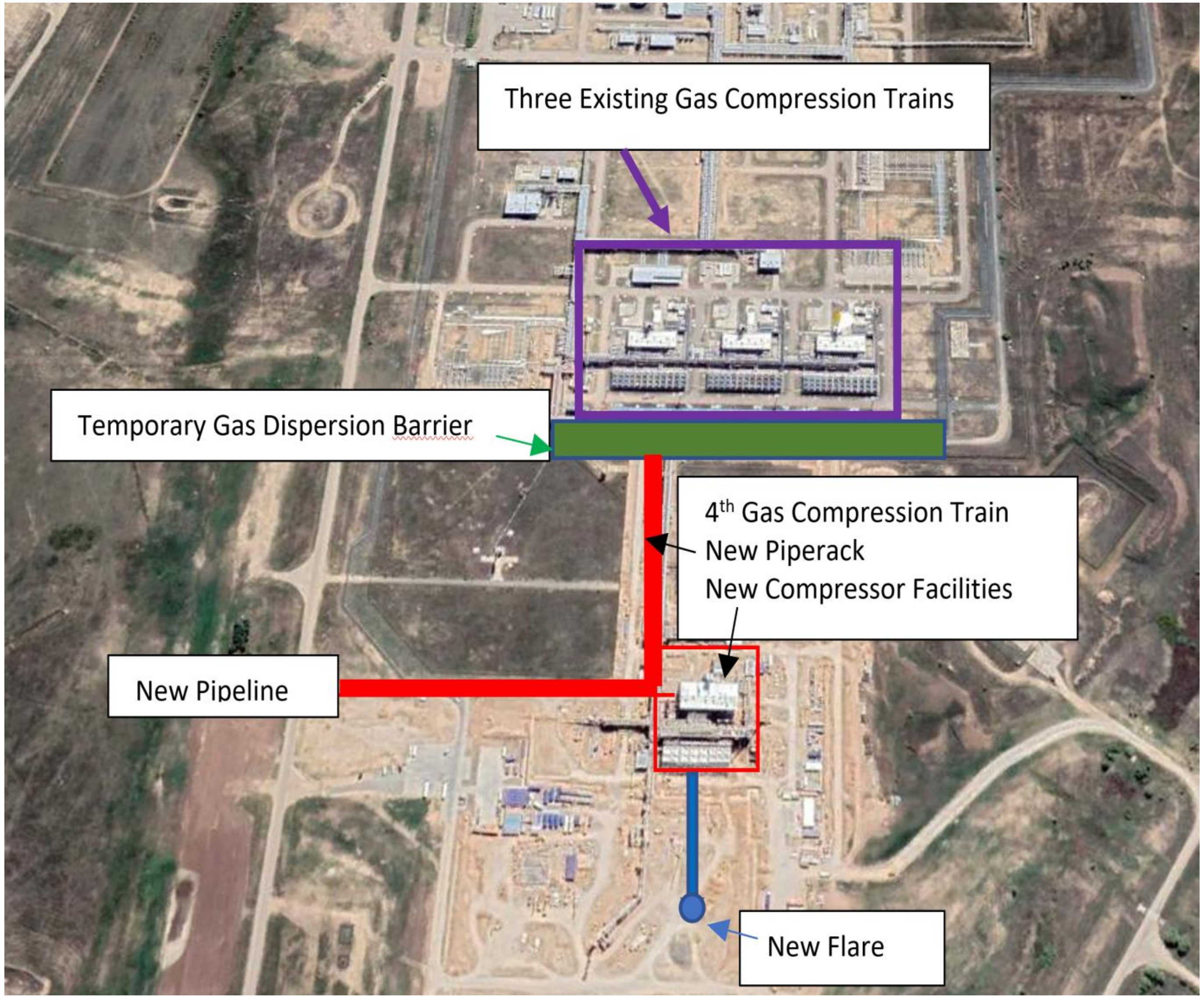
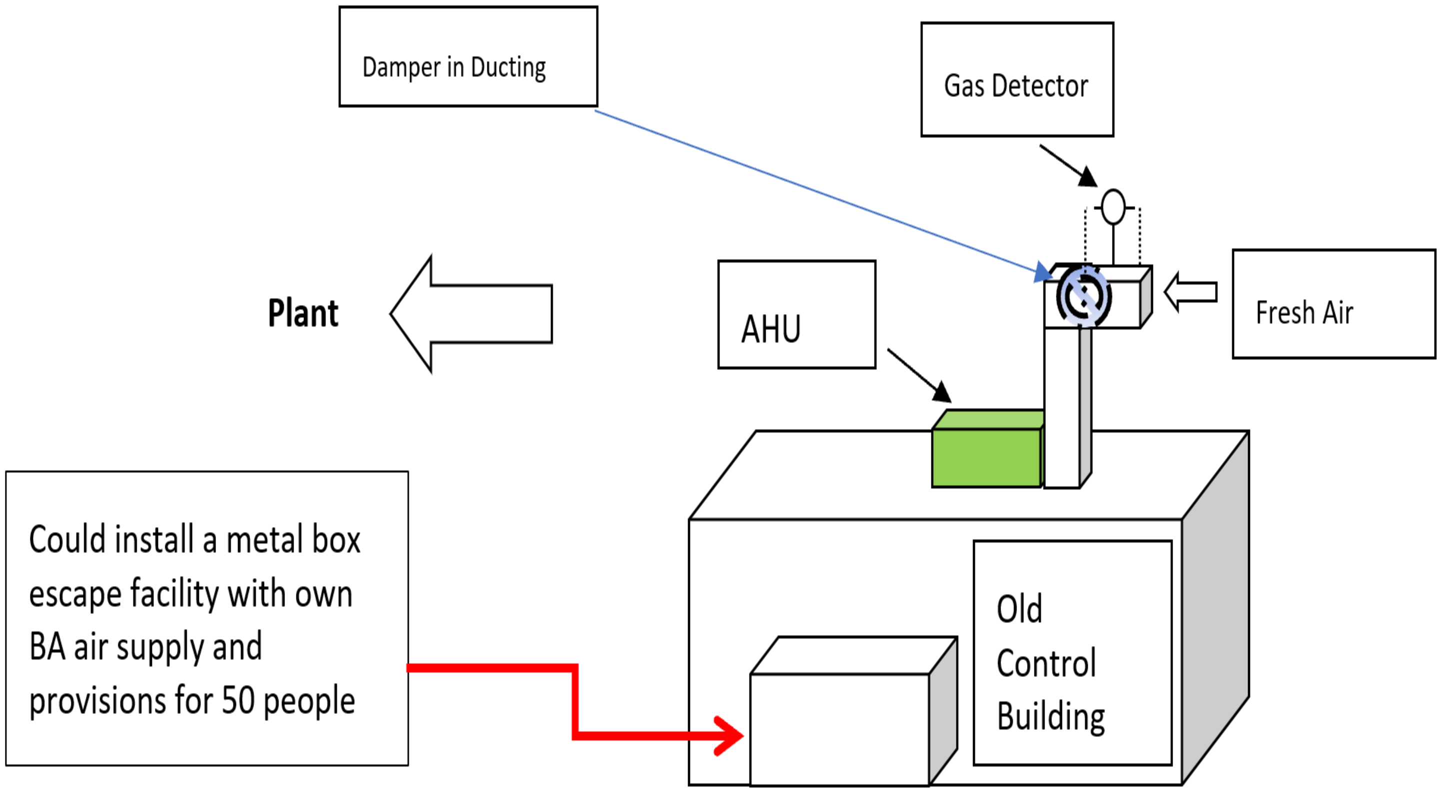
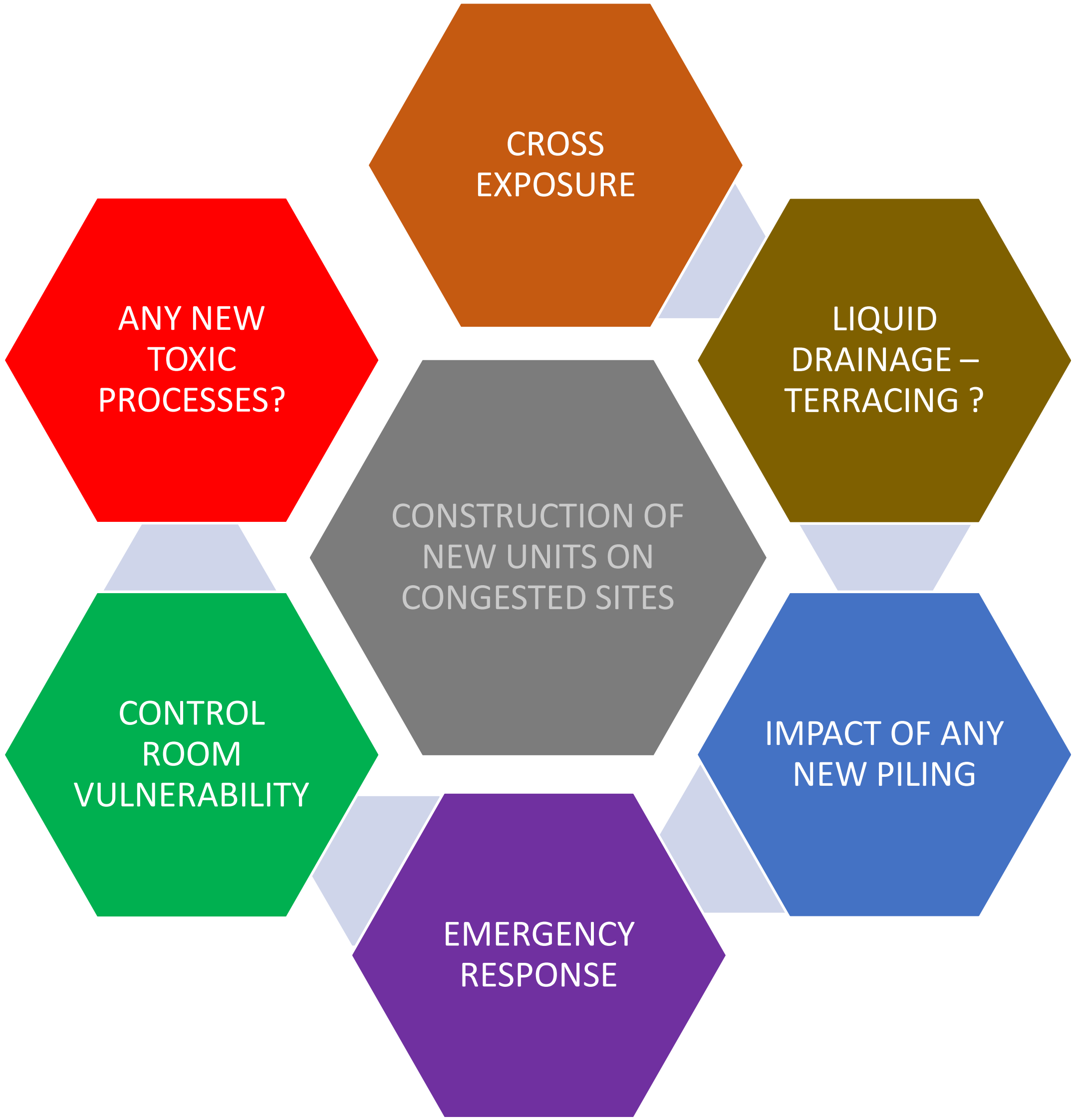


Figure 4

Control Room Orientation, Gas Ingress Prevention, Temporary Safe Refuge

This Case Study shows a possible solution for an old Control Building to protect the workforce. The Control building has minimum blast resistance and it was recommended that a metal box structure be annexed to provide a TSR for personnel. The existing air conditioning was also fitted with gas detection closing a damper to prevent gas ingress and double doors were installed.

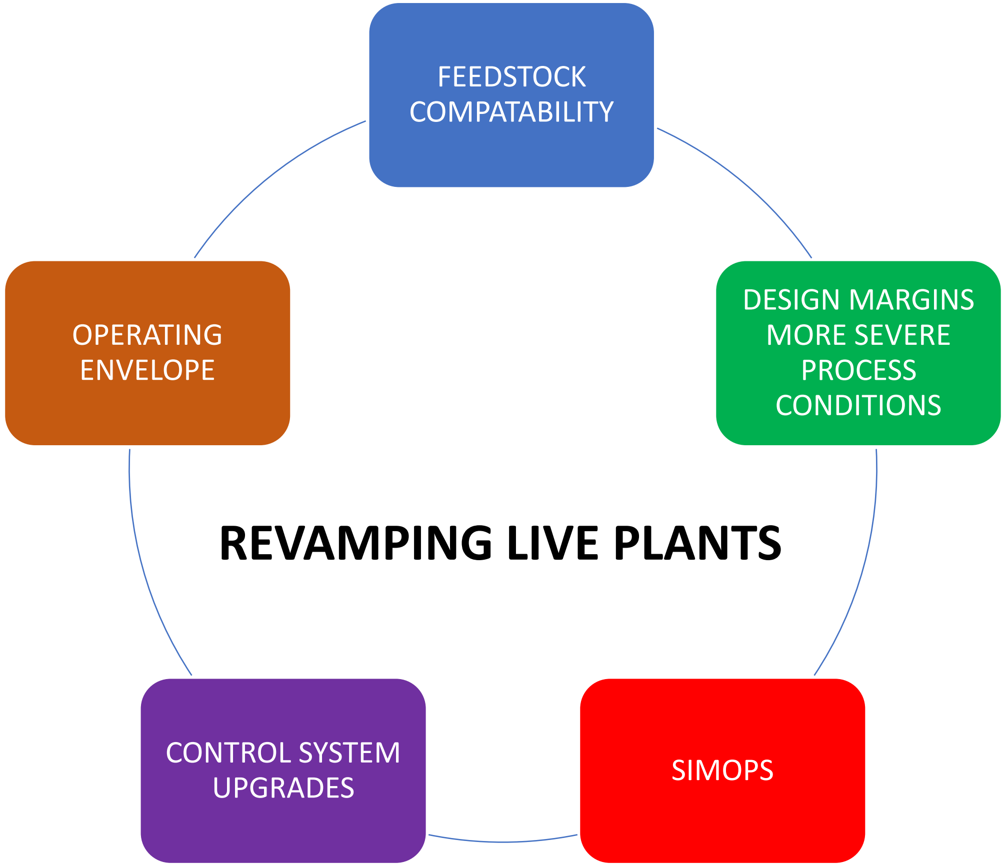




MODEL POTENTIAL FIRE, VCE, GAS/LIQUID RELEASE CASES

CHECK EXPOSURE TO UTILITIES, CONTROL ROOM

CONFIRM FIREWATER ROUTES, ACCESS FOR EMERGENCY RESPONSE



PROBLEM AREAS

CHANGING INTERNALS - EFFECT ON TURNDOWN
INCREASED TEMPERATURES – AIR COOLER BUCKLING

EXCAVATION – UNKNOWN AREAS (BURIED PIPELINES)
LIFTING OVER LIVE PLANT, FOUNDATIONS
UNCLASSIFIED EQUIPMENT IN HAZARDOUS AREAS
OPENING LIVE FLANGES

WELDING QUALITY
POOR STRESS ANALYSIS ON PIPEWORK, NOZZLES
HOT TAPPING CONCERNS
ADEQUATE ESD VALVES TO ISOLATE INVENTORIES
CONTRACTOR WORK AREAS FOR SPOOL PRPARATION
REMOVAL OF REDUNDANT EQUIPMENT

INTERSPACING OF EQUIPMENT
- INCREASED FIRE RISK CAUSED BY CLOSER SPACING
- MAINTENANCE ISSUES
- CONGESTION INCREASES POTENTIAL BLAST OVERPRESSURES

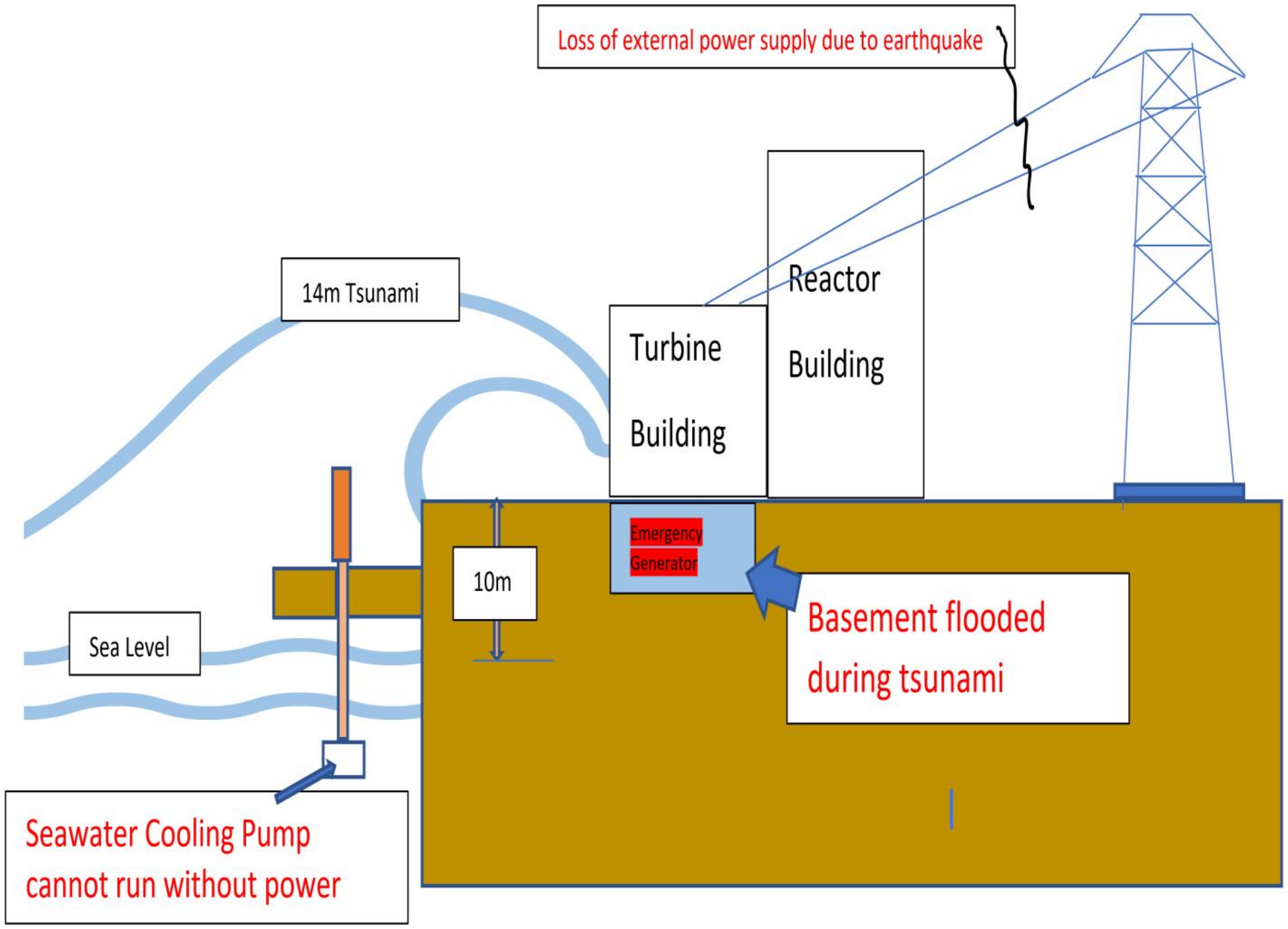
STORAGE TANK LAYOUT
- DO NOT MIX DIFFERENT TYPES OF STORAGE TYPES
- LOCATE PRESSURIZED STORAGE AWAY FROM PROCESS AREAS
- BUNDING – VOLUME ADEQUATE, SEALING OF PENETRATIONS

ISOLATION OF INVENTORIES
IGNITION SOURCES
FLARE/VENT LOCATION
- ISOLATION OF INVENTORIES IN EMERGENCIES
- TRY TO ELIMINATE ALL IGNITION SOURCES
- REMOTE STERILE AREAS FOR FLARES, NO VENTS TO ATMOSPHERE IN PLANTS

PLANT DRAINAGE
- DRAINAGE MUST COPE WITH STORM WATER AND FLOW FROM INCREASING PAVED AREAS. BLOCKED SEWERS

CASE STUDY 1 – FUKASHIMA EMERGENCY GENERATORS ROOM FLOODED

– NO POWER SUPPLIES TO RUN COOLING SYSTEMS FOR REACTORS DUE TO EARTHQUAKE HALTING GRID SUPPLIES & THEN TSUNAMI PREVENTING EMERGENCY GENERATORS FROM OPERATING

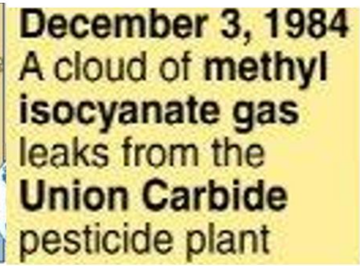


CASE STUDY 2 - FEYZIN BLEVE EVENT RESULTED FROM A PROPANE LEAK WHICH ESCALATED

DRAINAGE OF THE BUND TO AN IMPOUNDING PIT SHOULD HAVE BEEN INSTALLED

CASE STUDY 3 - BHOPAL TOXIC GAS RELEASE

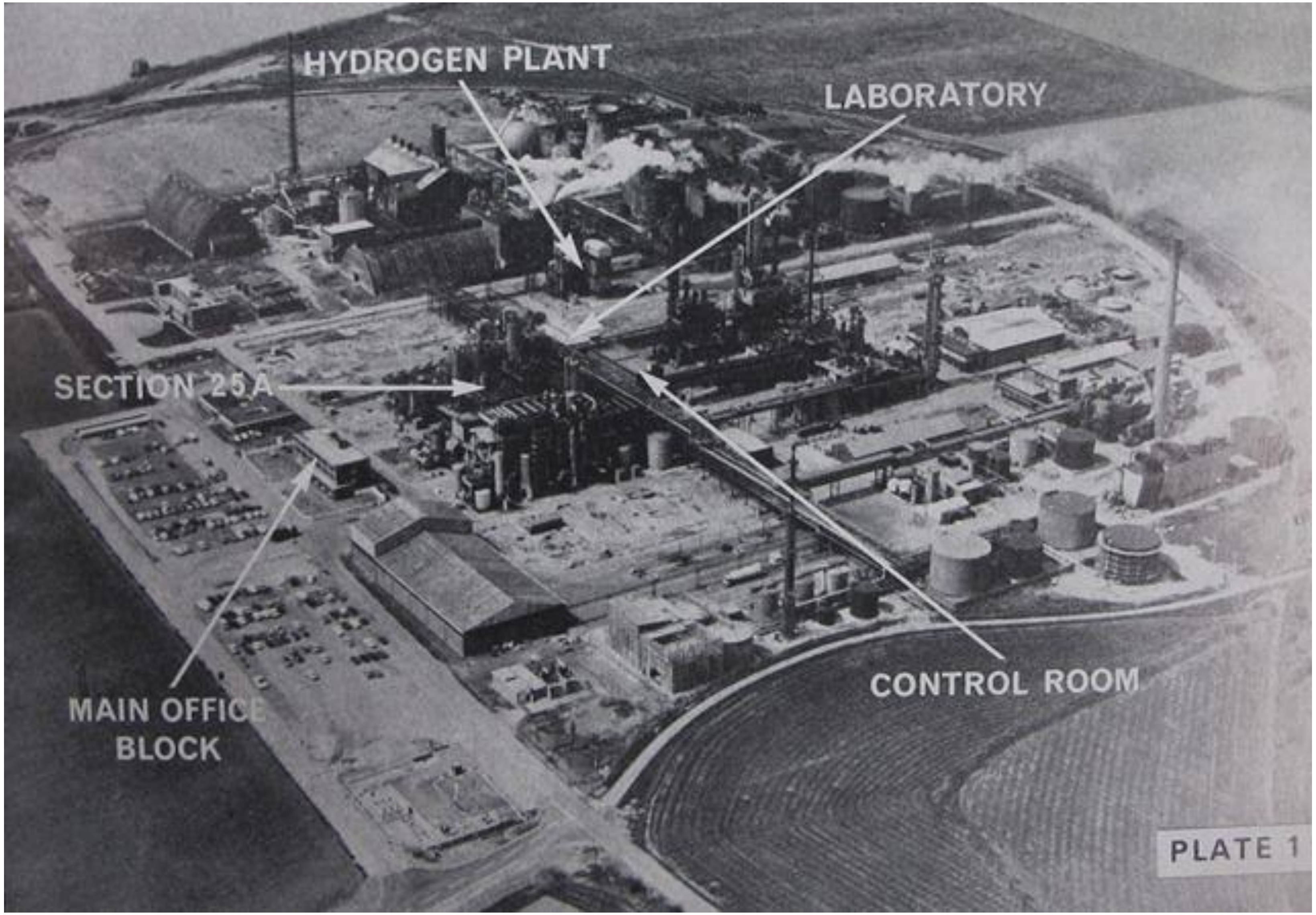
POOR LOCATION OF TOXIC CHEMICAL PLANT IN A HEAVILY POPUPLATED AREA TOGETHER WITH POOR MAINTENANCE & FAILURE TO FOLLOW PROCEDURES


December 3, 1984
A cloud of methyl isocyanate gas leaks from the Union Carbide pesticide plant

The cloud drifts over the city area resulting in a high level of poisoning of inhabitants

CASE STUDY 4 - FLIXBOROUGH

POOR CONTROL ROOM
DESIGN & LOCATION – MINIMUM BLAST RESISTANCE AND IN CENTRE OF PLANT CLOSE TO PROCESS



CASE STUDY 5 – PIPER ALPHA

POOR RISK ASSESSMENT ON EXPANSION OF PLATFORM –
GAS PIPELINES UNDER ACCOMMODATION –
TOO MUCH SIMULTANEOUS REVAMP/EXPANSION WORK ON A LIVE FACILITY