EFU GENERAL INSURANCE

SPECIFIC RISKS
AND LOSS EXAMPLES FOR POWER PLANTS

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ELECTRICITY GENERATING PLANTS

1. CONVENTIONAL FOSSIL FIRED POWER PLANTS including STEAM TURBINES
2. GASTURBINE / COMBINED CYCLE POWER PLANTS
3. NUCLEAR POWER PLANTS
4. HYDRO-ELECTRIC POWER PLANTS
5. WASTE FIRED POWER PLANTS
6. ALTERNATIVE POWER PLANTS (sun, wind, geothermal, tidal, etc.)

Primary Sources of Energy

Fossil Fuels
Nuclear Fuels
Hydro Power
Wind Power
Solar Power
Biomass/Waste

→ **Main Fossil Fuels**

+ **COAL**
- **lignite or brown coal**
- **bitum. or hard coal**

+ **NATURAL GAS**

+ **OIL**

Diesel Engine Power Plant

Fire in the Power House

Fire

Significant fire load due to:

- Oil lubrication, hydraulic systems
- Hydrogen (for cooling purposes of the generator)
- Isolating liquids
- presence of combustibles

and

- high superficial temperatures
- welding works, etc.

Prevention of oil fires

Use of special hydraulic liquids with a high ignition temperature

Position of the turbine valves

Use of special protected tubes and separation from the steam tubes; welding connections instead of screwed pipe connections

Fire and Explosion within the Boiler

Fire caused by

- Auto-ignition of combustible
- Welding works
- Rupture of hoses for combustible (gas, oil)
- Leakage of hydraulic fluids
- Ignition of dust in the air pre-heater
- Failure of mechanical parts
- Maintenance works in the DeSOx plant

Coal dust explosion or flue gas explosion within

- Boiler or
- Electrostatic precipitator

Boiler explosion

Boiler explosion

Typical mechanical damage

Tube rupture by

- over pressure
- Vibrations
- overheating (lack of water)
- wear and tear, corrosion, erosion

Rupture of feed water tank by

- over pressure
- over temperature

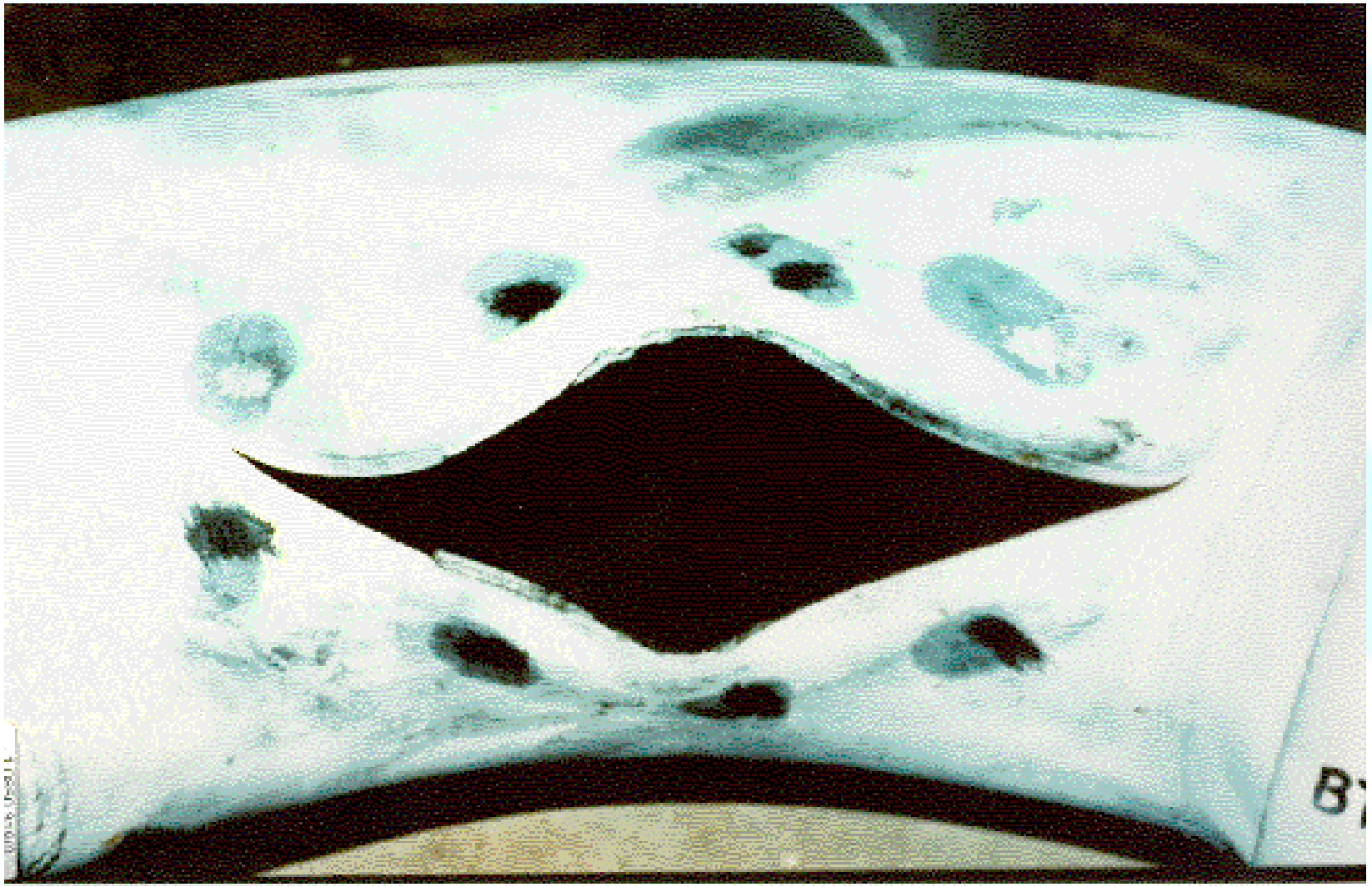
Deterioration of components (pre-heater, ducts, precipitator) by

- Accumulation / Penetration of ashes

Lack of cooling water supply due to

- Failure of feedwater pump (redundancy required)

A typical mechanical damage in a boiler



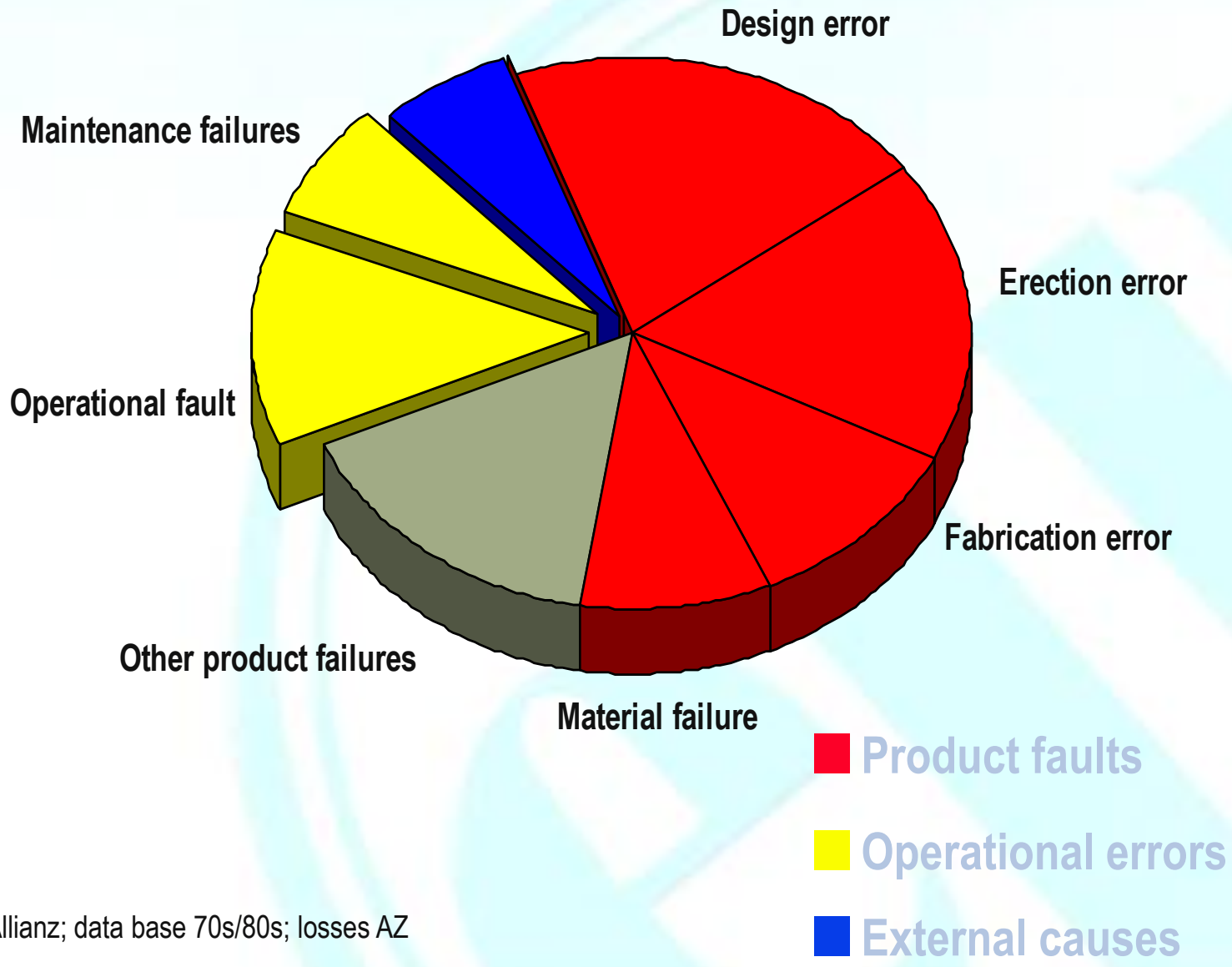
Mechanical damage in steam turbine

Typical Mechanical Damage

- Blade failure due to vibrations or thermal stress
- Blade rubbing due to failure of radial or axial bearings (e.g. by failure of lubrication)
- Blade rubbing / deformation of blades due to unforeseen thermal
- Fissures / fatigue of the casing / rotor by thermal stress
- Overspeed due to failure of the steam valve or due to failure of the control system
- short circuit
- Overspeed due to generator trip

Blade Rupture in Turbine

Losses to steam turbines



Source: Allianz; data base 70s/80s; losses AZ

Steam Turbine Disintegration

Disintegration of LP rotor

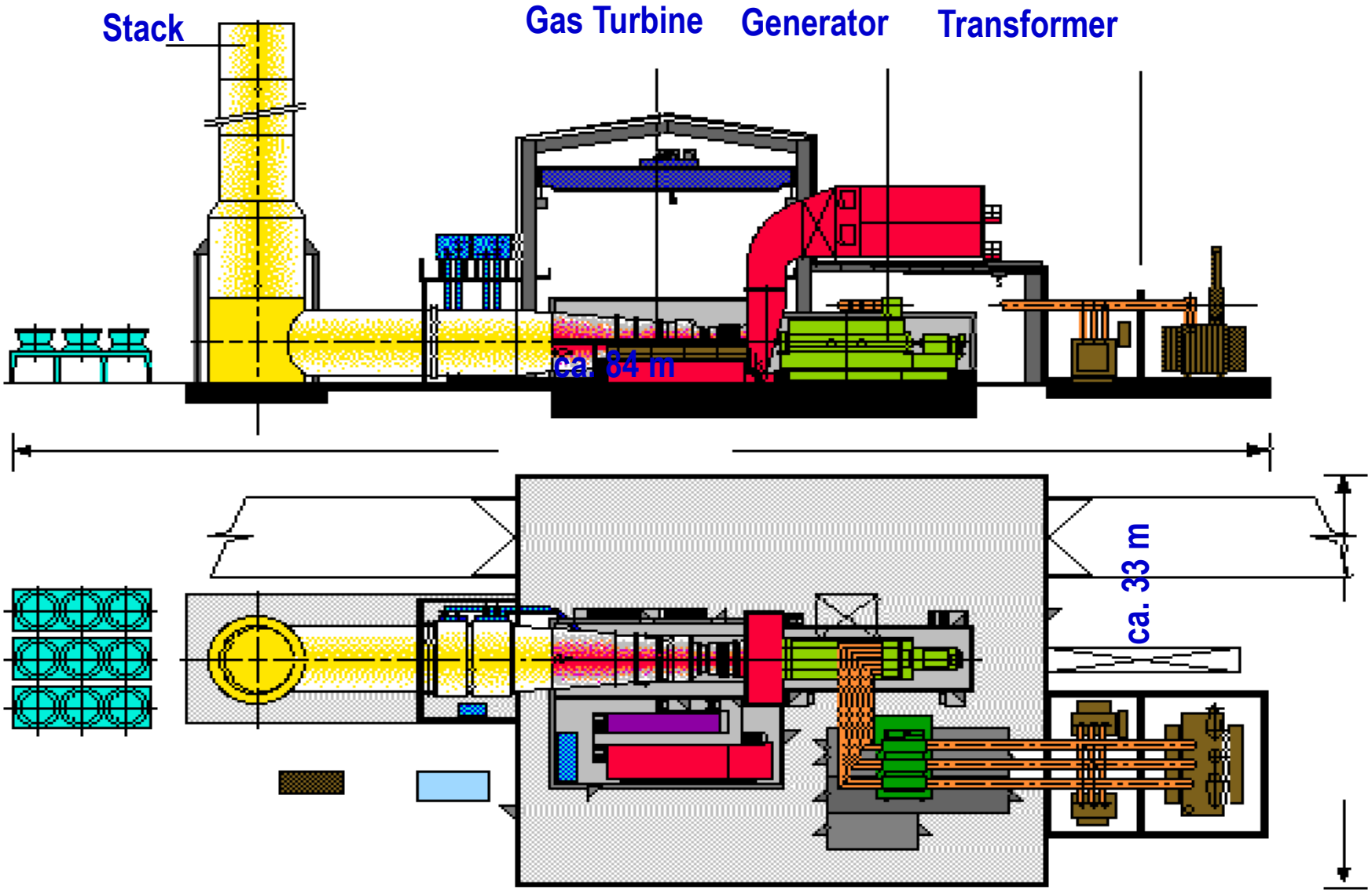
A loss in a steam power plant

Components of a Gas Turbine

• **Compressor**	blades / (adjustable) guide vanes
• **Combustion chamber**	annular / silo burners / cladding
• **Gas Turbine**	blades / vanes / cooling system
• **Rotor**	forged disks: tie bolts / welded thrust and journal bearings lubrication system
• **Exhaust gas channels**	diffuser / stack
• **Turbine casing**	foundations

Gas Turbine Power Plant

(simple cycle)

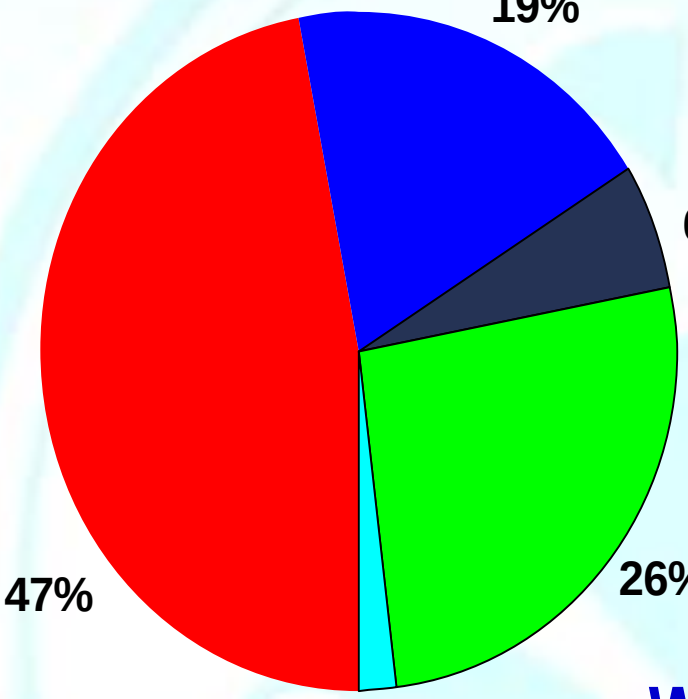


Gas Turbine Manufacturers

- ABB / Alstom
- General Electric
- Siemens / Westinghouse

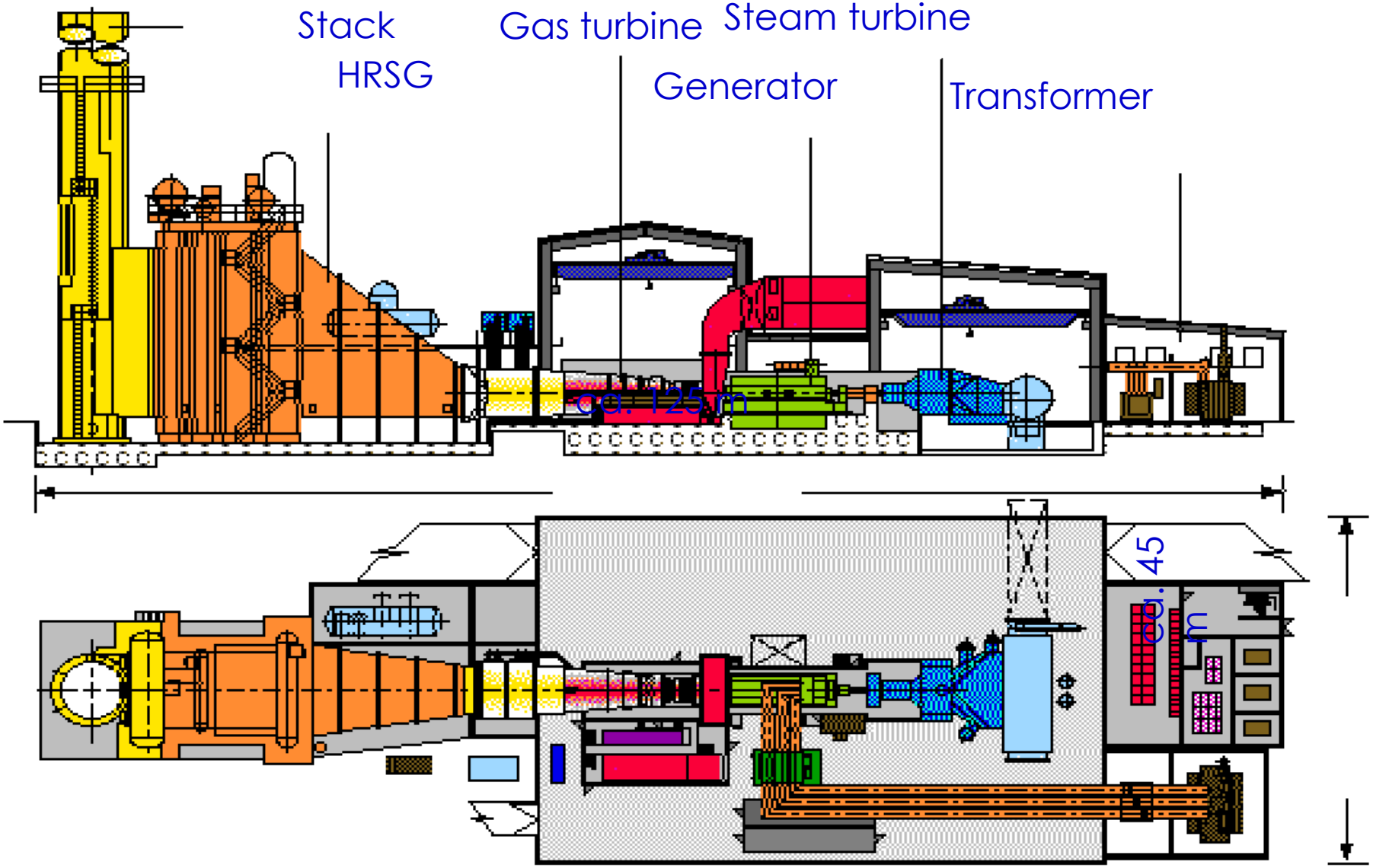
- Mitsubishi

World Gas Turbine Market (1998-05)



Source: GE

Combined Cycle Power Plant single shaft

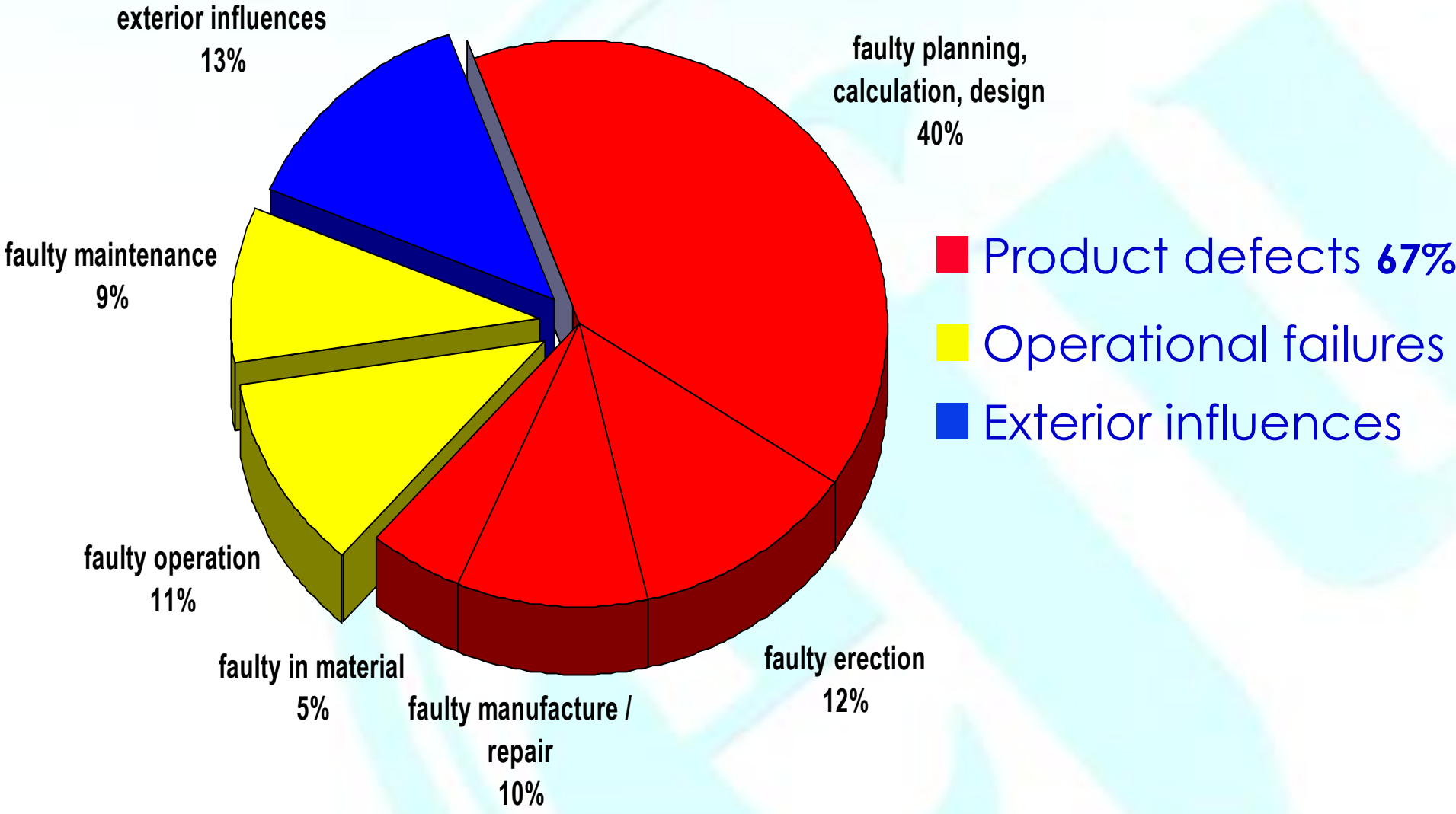


New Gas Turbine Technology

Loss potential:

- Higher thermal stresses and elongation's
- Overheating, uneven distribution of heat
- Rubbing of rotating parts
  (smaller tolerances, at larger thermal elongation)
- New and unproven materials
- Unexpected behaviour/ losses from unproven modifications

Causes of Loss in Stationary Gas Turbines



Typical mechanical losses to GT's

- Excess temperature in the "hot gas path"
- failure of cooling system
- Rupture, fissures or mechanical fatigue of turbine blades due to vibration
- damage to turbine blades due to foreign objects
- rubbing due to rotor movements or deformation

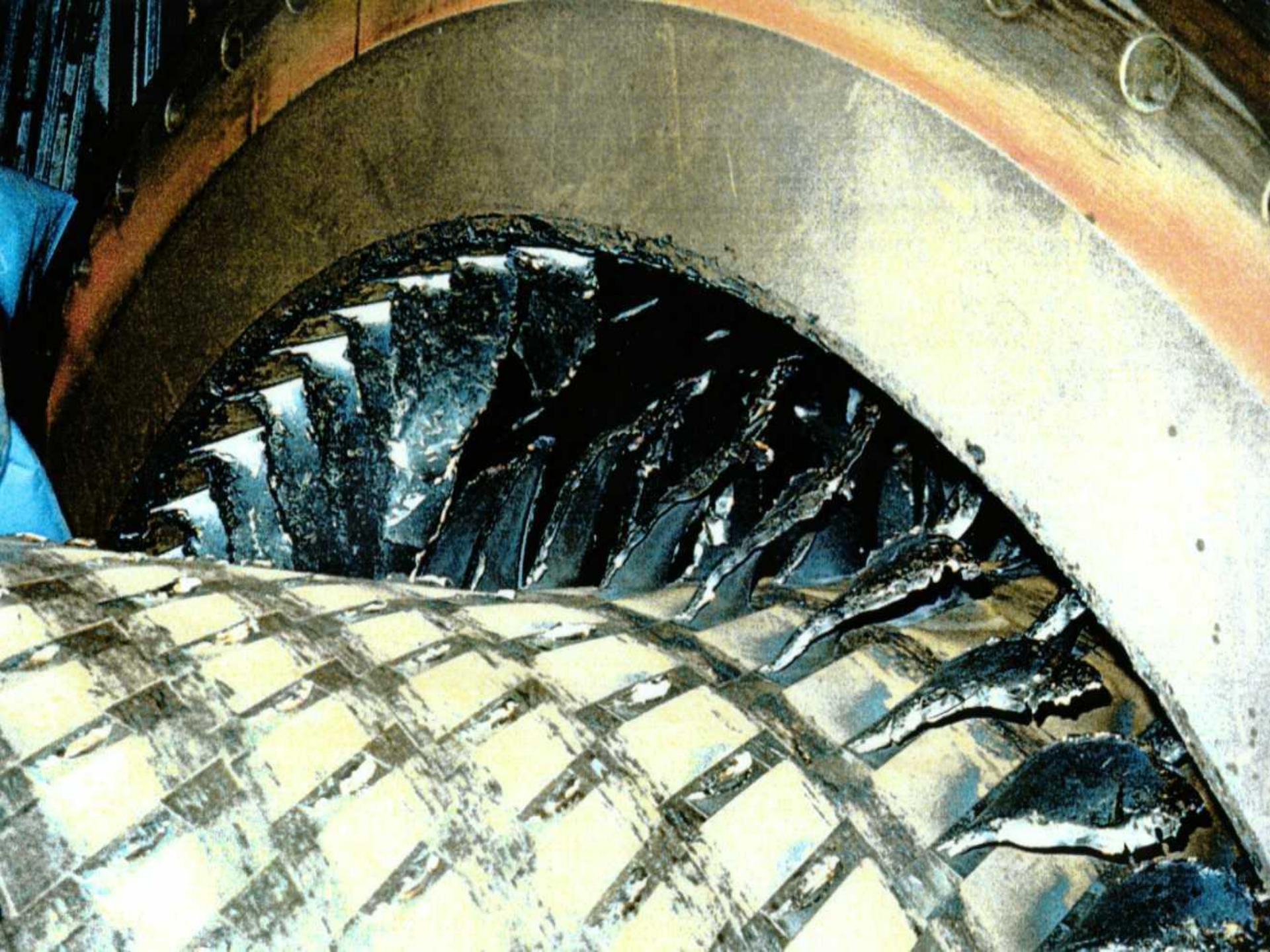
Typical mechanical losses to GT's

- Fissures or fatigue in the combustion chamber due to thermal stresses
- gear box failure
- electrical failures in generator
- Generator trip at full load - over speed

A loss in a gas turbine

Technical details:

- **CCPP with a gas turbine of 240 MW**
- **Total loss to compressor and within combustion chamber**
- **Cause: rupture of 2nd row compressor blade**
- **Material damage US$ 33 millions**
- **Plant outage for 8 months**



Typical Risk Exposures of a Power Plant

1. ***Detectors in Standby Generator House***

   We recommended that a smoke detector be installed in the standby generator house. In addition we also suggested that the cable penetrations in this room be sealed with an approved fire barrier seal.

2. ***Manual Fuel Shut Off Valve***

   We recommended that the manual fuel shut off valve should be more easily accessible for rapid action. A chain had provided quick action earlier but this had been removed due to inadvertent operation in the past

3. ***Flammable Materials in Warehouse***

   We recommended that all flammable materials be removed from the warehouse and stored in an isolated storage area.

4. ***Blast Walls Main Transformers***

   Although a SERGI system may be fitted at the transformers we suggested that engineers should re-evaluate whether blast walls fitted to protect adjacent transformers would be beneficial. The manager agreed to carry out this review.

   Electronic systems have a habit of failing and should the SERGI system fail to operate the adjacent transformer could be damaged.

Warehouse

Fuel Oil Shut Off Valve

Switch Yard

Transformer Compound

Transformer Bays

5. *Cablespread Penetration Sealing*

We explained to managers and engineers during our visit the vulnerability of the underground cable spread areas and tunnels to low order of probability catastrophic fire incident. We recommended that fire barriers were required between the engine house, the cable basement and cable tunnels to limit the spread of fire incident along cables. Management appreciated the problem following our discussions and agreed to carry out a review and initiate action at an early date.

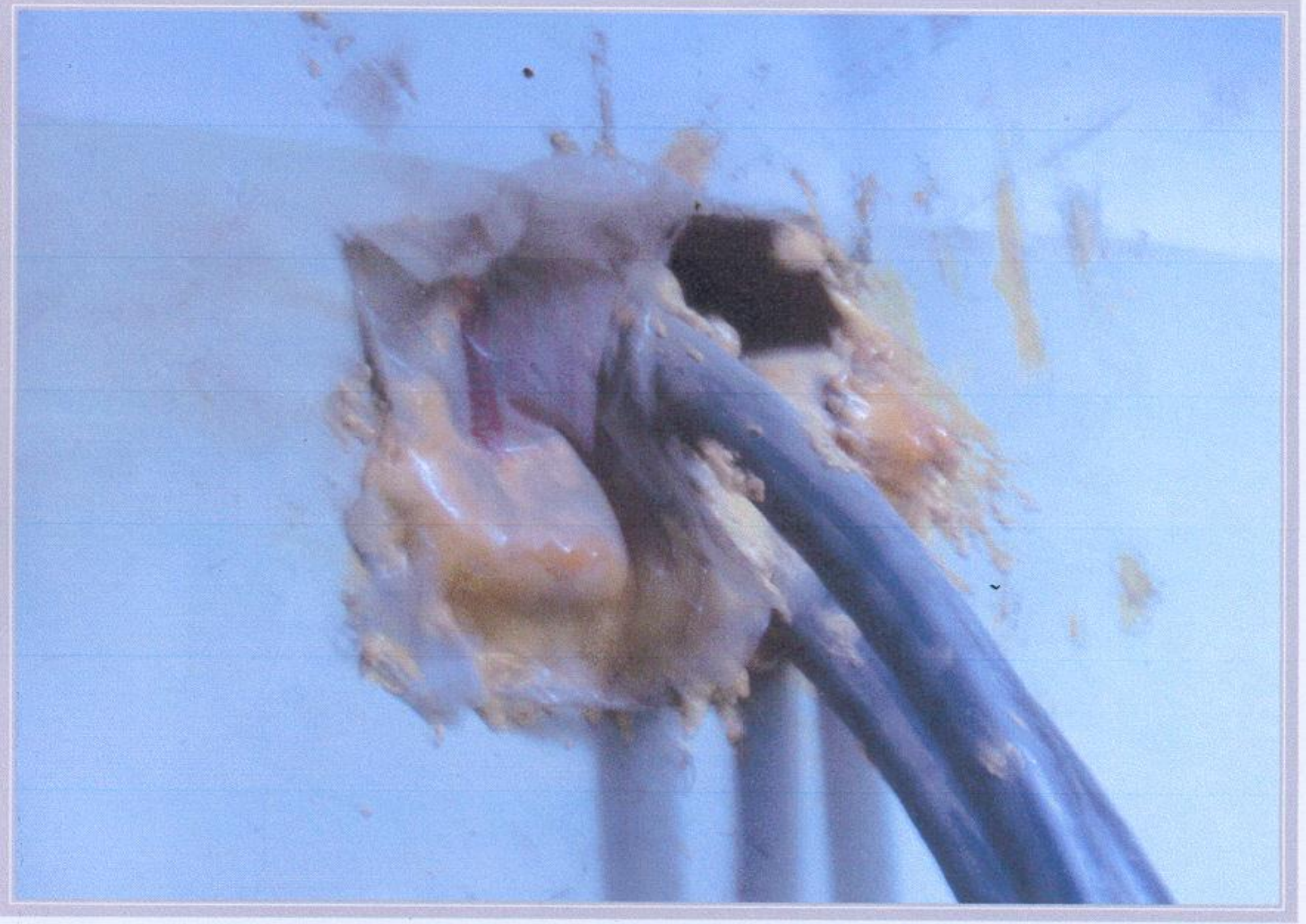
The objective should be to barrier and seal off large open penetrations from fire and smoke passage to limit the spread of fire incident wherever it initiates. Smaller penetrations such as cable should be sealed with an approved foam sealer. Underwriter Laboratory (UL) and Factor Mutual (FM) approved barrier material, paint and sealers set the standards to apply.

6. *Fuel Oil Pumphouse*

We recommended that a fire detector be installed in the fuel oil pump house.

7. *Cable Trays Beneath Engines*

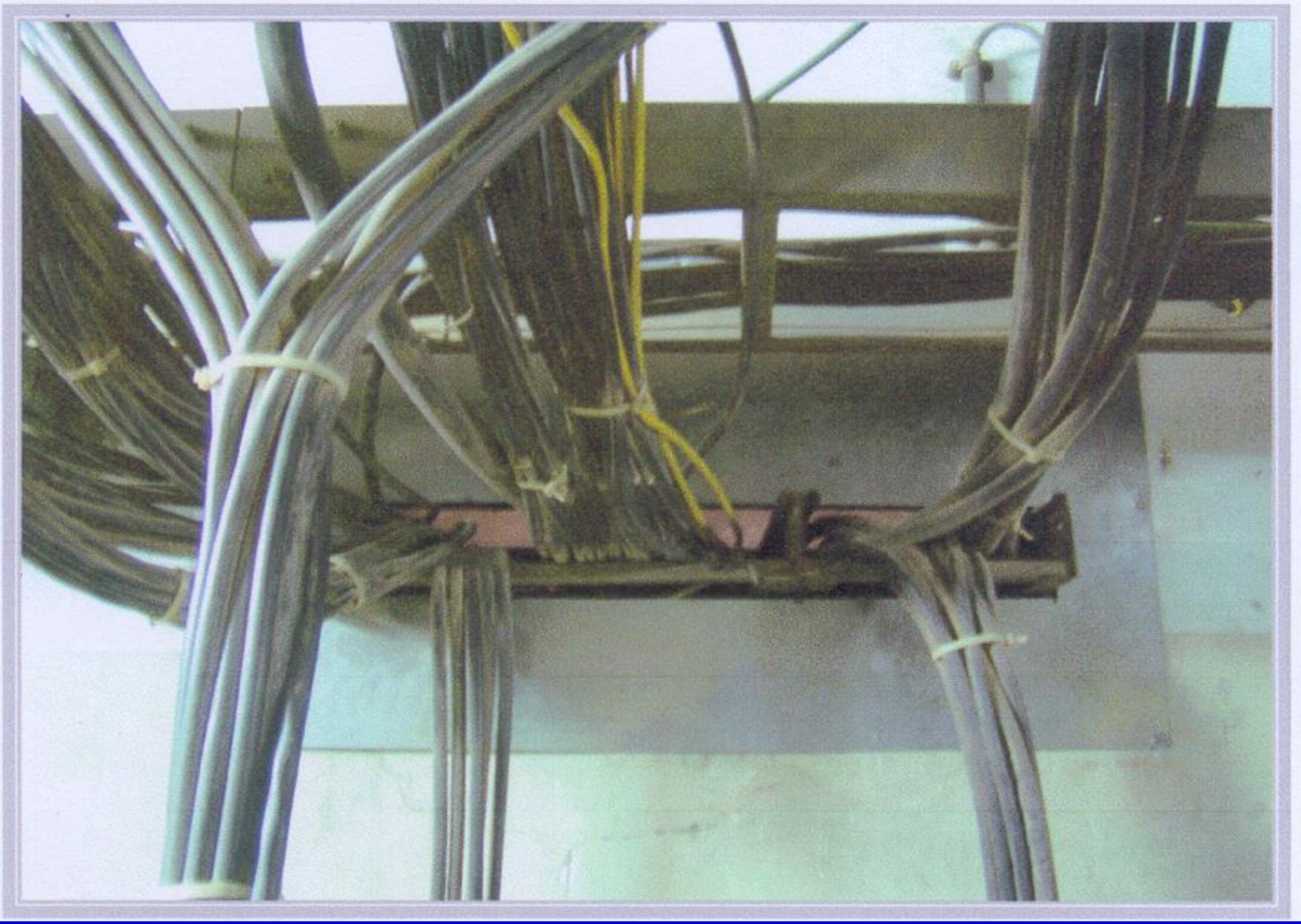
At our survey we recommended that an evaluation be carried out into the vulnerability, from a business interruption viewpoint, of the cable trays and the area which runs below the generating sets.



Partial Sealing of Cable Run Penetrations of Basement Walls

Effective Fire-Stopping on Cable Tray Penetration through external wall of Engine room above Ground level

General Poor Condition of Engine Crankcase



Lack of Fire Stopping on Cable Runs in Engine Room Basement

Fuel Oil Pump House

Centrifuge and Fire Valves Fuel Oil Pump House

8. *Emergency Procedures*

We recommended that an emergency procedure be made readily available to everyone at the facility especially in the main control room. The procedure should include all the aspects we discussed at our visit including responsibilities and actions to be taken. We noted that a document had been prepared and we were assured that it would be implemented as soon as possible.

The reason for recommending this were obvious and accepted by management.

The engineering and financial implications are minimal.

9. *Vibration Alarm*

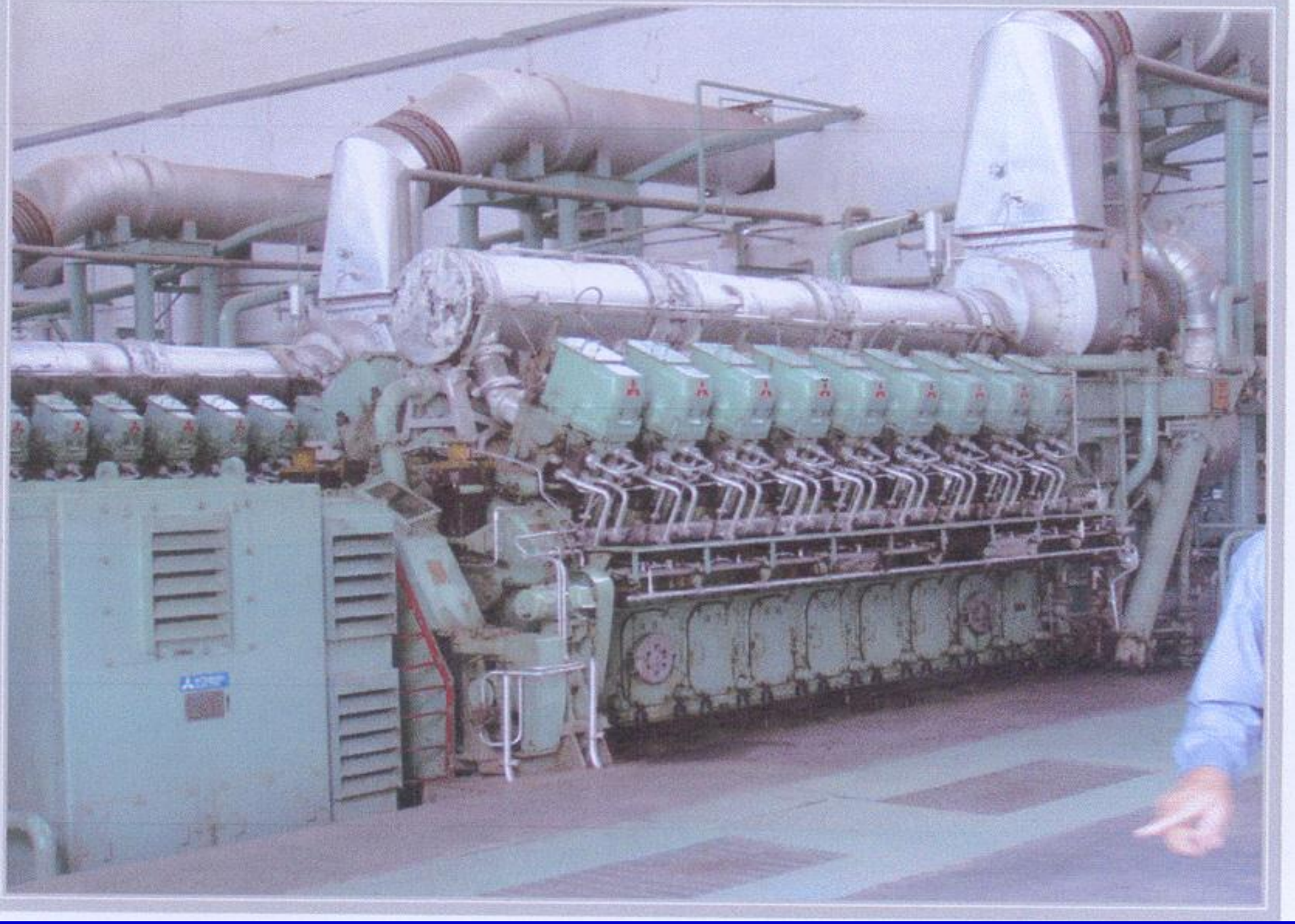
Standing high vibration alarms on local panels should be investigated immediately. We noted a high vibration alarm on the local steam turbine panel. This was investigated immediately we noted the fact and cleared. The fact that an alarm such as this is able to stand, without notification in the control room, requires investigating as discussed at our survey.

10. *Fire Valve Strapping*

We recommended that all fire valves be strapped in the operational position with plastic ties. Management readily agreed to do this.

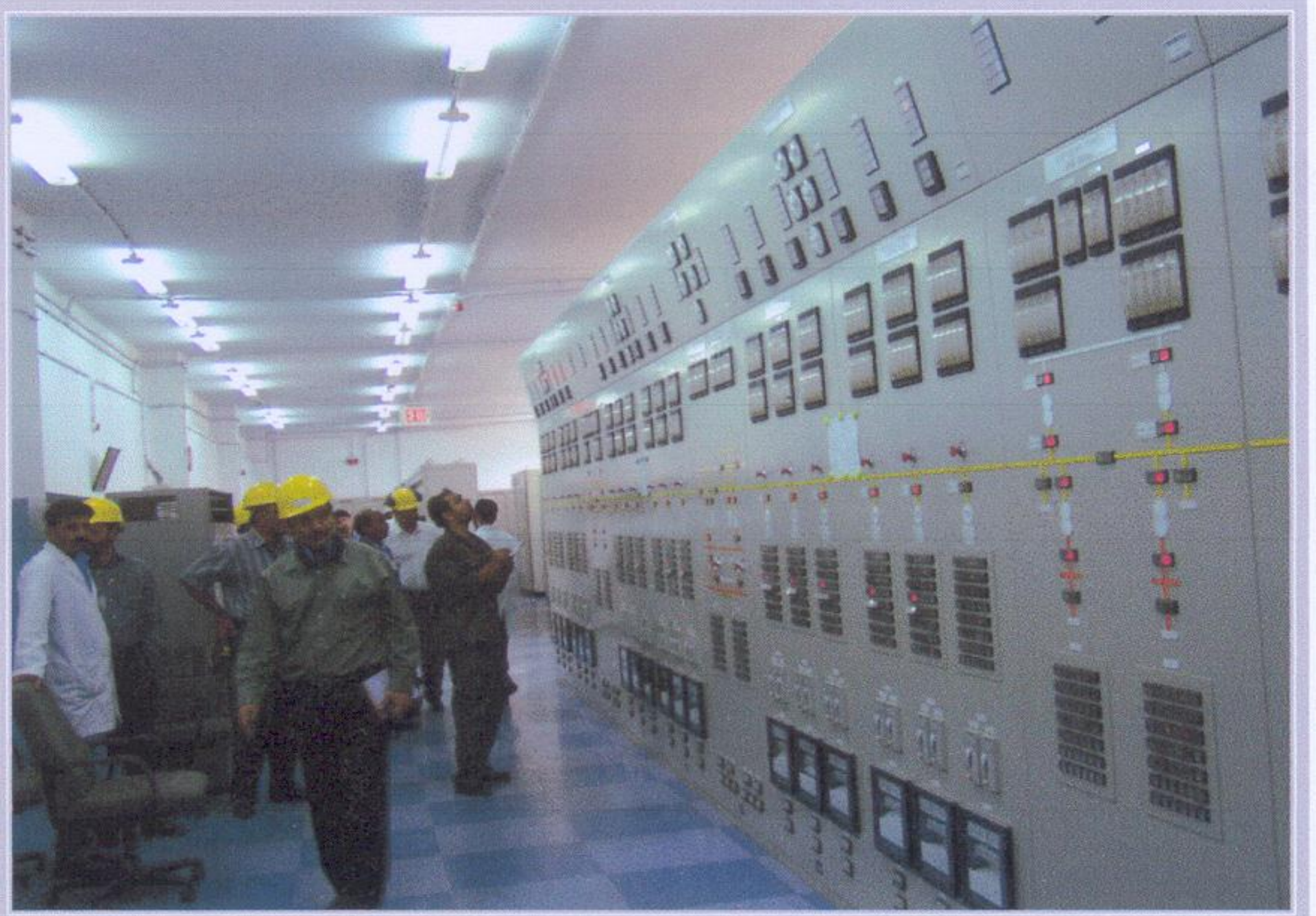
This will ensure that the valves cannot be unnecessarily tampered with.

The Engine House



Oil Staining Around Base of Engine

Control Room



Control Room

11. *Emergency Alarm System*

We suggested to the General Manager that he may wish to consider the installation of a location wide emergency "break" alarm system to which he agreed.

The existing alarm system is limited to key areas and even though all facility personnel carry a radio during outage periods an alarm system could prove to be a positive safety addition.

12. *Cables Over Lubricating Oil Tanks*

The steam turbine lubricating oil tank is neither bunded or has an sprinkler system installed. Fracture or rupture of the tank and its pipework is a very unlikely event and as a result of the general layout and expense involved we do not intend to recommend this. We would though recommend that the electrical wiring which passes over the tank be covered by a fire resistant covering which covers the area over the tank and for a distance of 20ft each side.

13. *Temporary Joints on Cable Trays*

We recommend that a review takes place to remove any temporary wiring joints on cable trays. We noted only one of these during our survey but are concerned that there may be others.

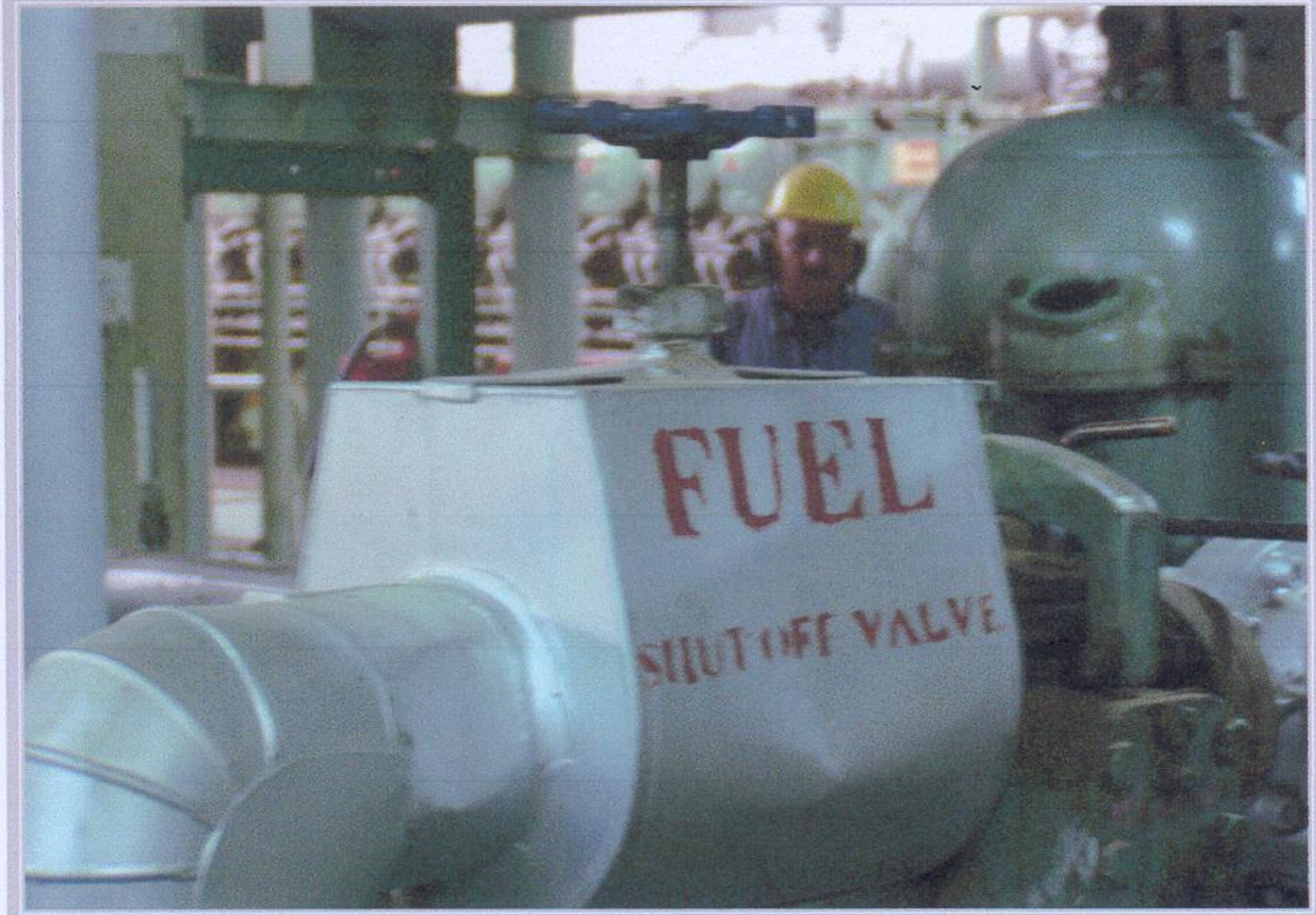
Steam Boiler

14. *Fuel Shut Off Valve at Engine*

We recommend that this valve be clearly delineated by clear marking so that in the event of a significant fire event at an engine the operator can rapidly utilise the valve to close off the oil.

15. *Fire Audit*

We recommended to management that a Fire Audit should be carried out as soon as possible, using a team of engineers from different disciplines within the power plant, over say a three day period. We explained how this could be carried out and that a report should be produced and presented to management setting out perceived problems, providing implementation priorities and financial value analysis for urgent action. The Manager agreed with this and indicated that our recommendation would be implemented.



All Fuel Shut-Off Valves now effectively Marked

Heavy Fuel Oil Tanks

Looking Inside Oil Tank Bunds

Fuel Loading Area

Fire Panel

Fire Pump House

Fire Simulation Test

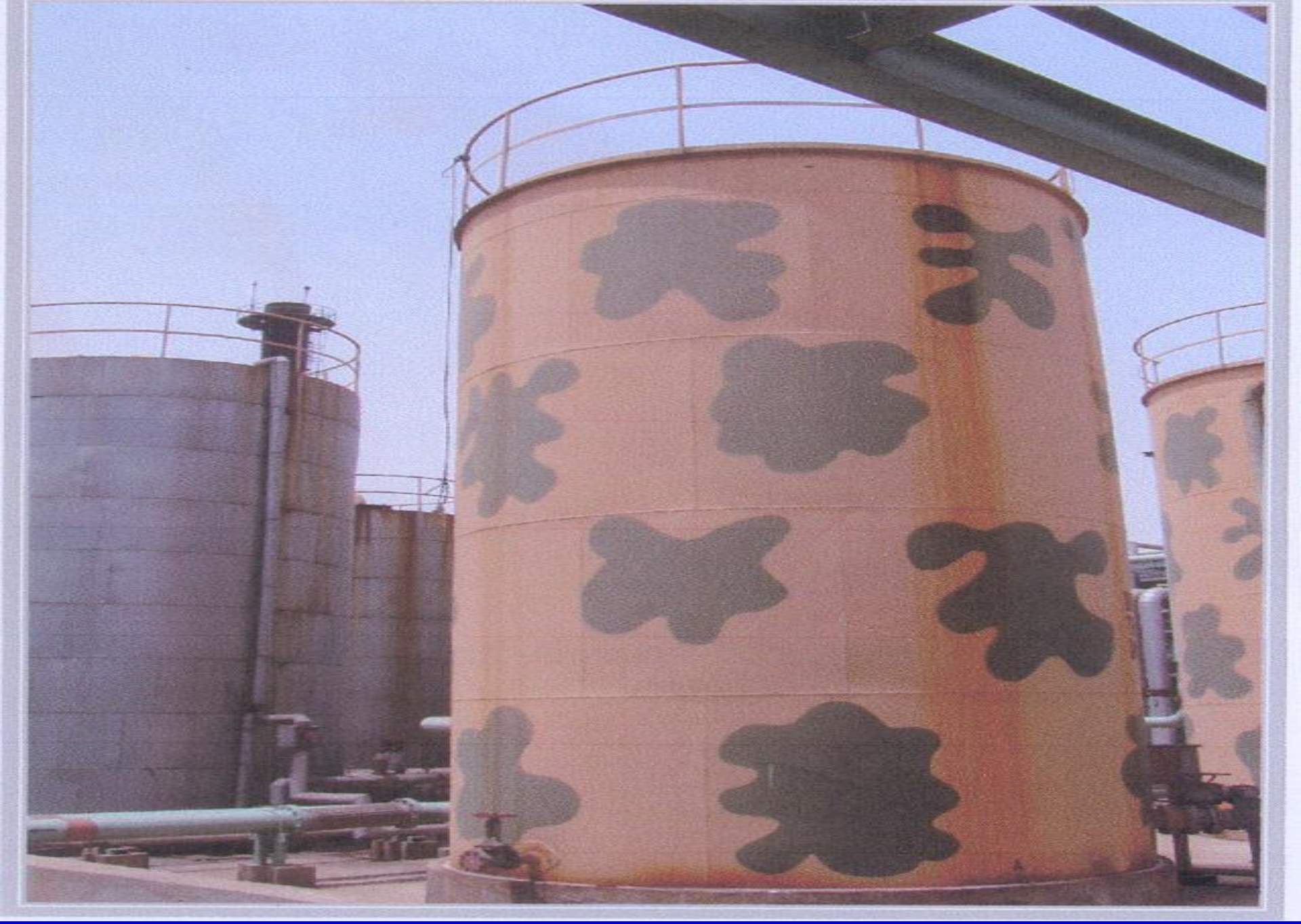
Fire Pump House

Hose Station

Fire Pump House

Combined Stacks

Rust Staining on Exhaust Stacks



Rust Staining on Storage Tanks