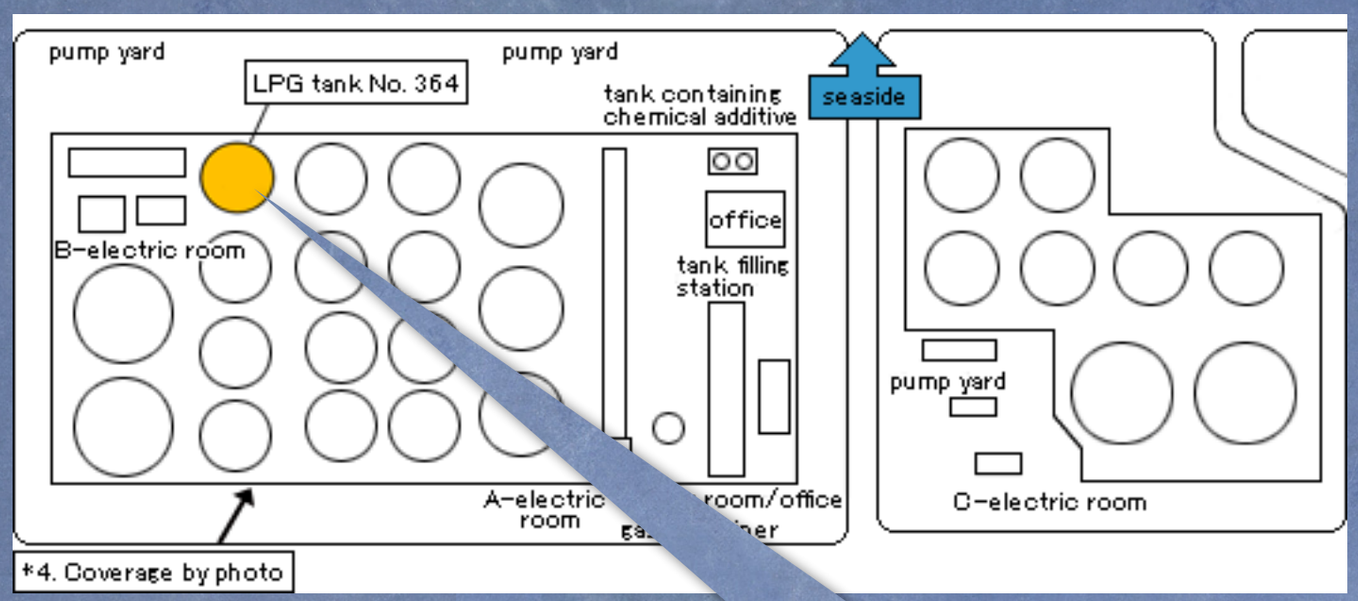
On Cosmo Oil Refinery, Ichihara, Chiba

Ahmed Farag
Anirban Chakraborty

What happened on March 11, 2011
at the Cosmo Oil Refinery, Ichihara, Chiba ?

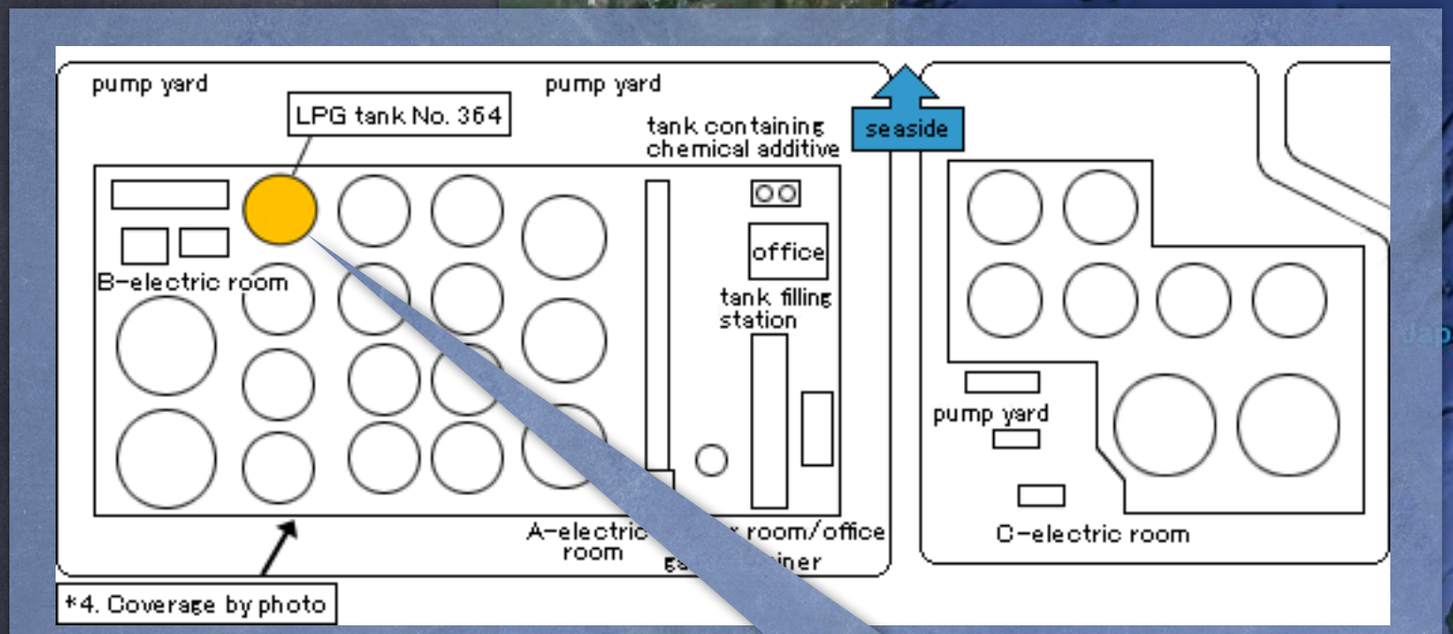
March 11 2011 14:46 HRS



COSMOS OIL REFIN CHIBA

GREAT EAST JAPAN EARTHQUAKE

March 11 2011 15:15 HRS

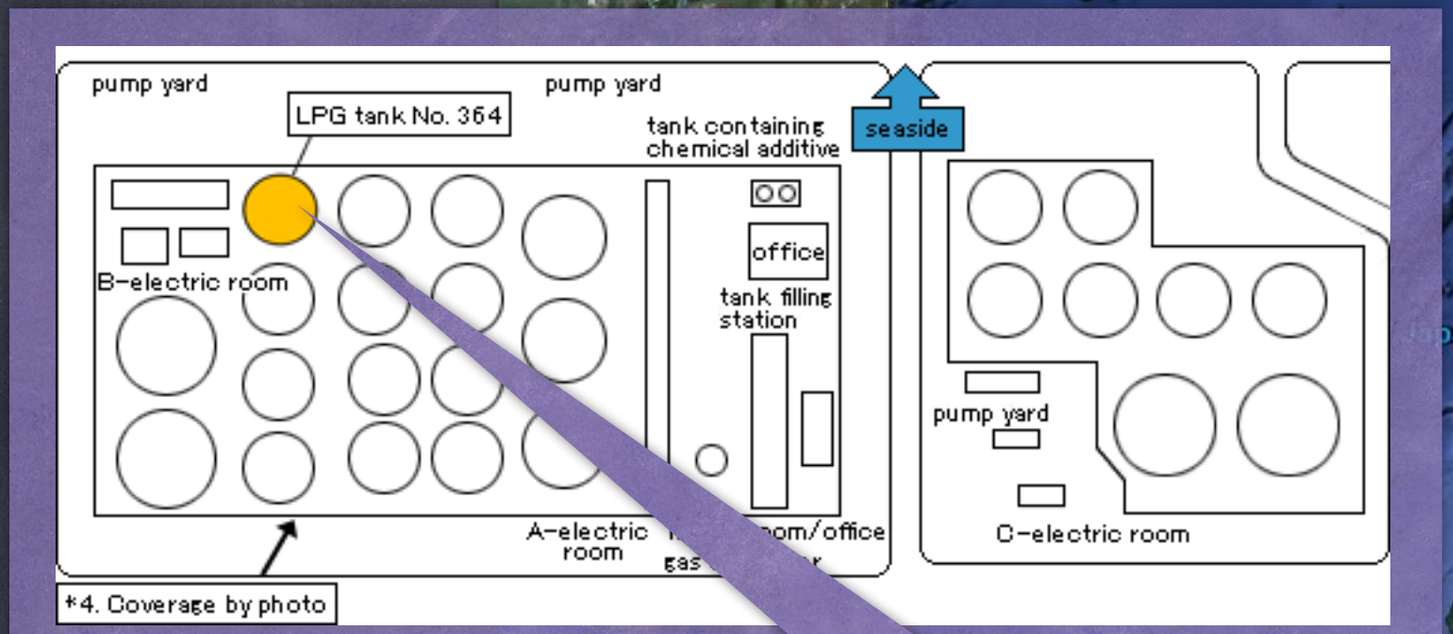


COSMOS OIL REFIN CHIBA

AFTERSHOCK

The legs failed and the tank collapsed

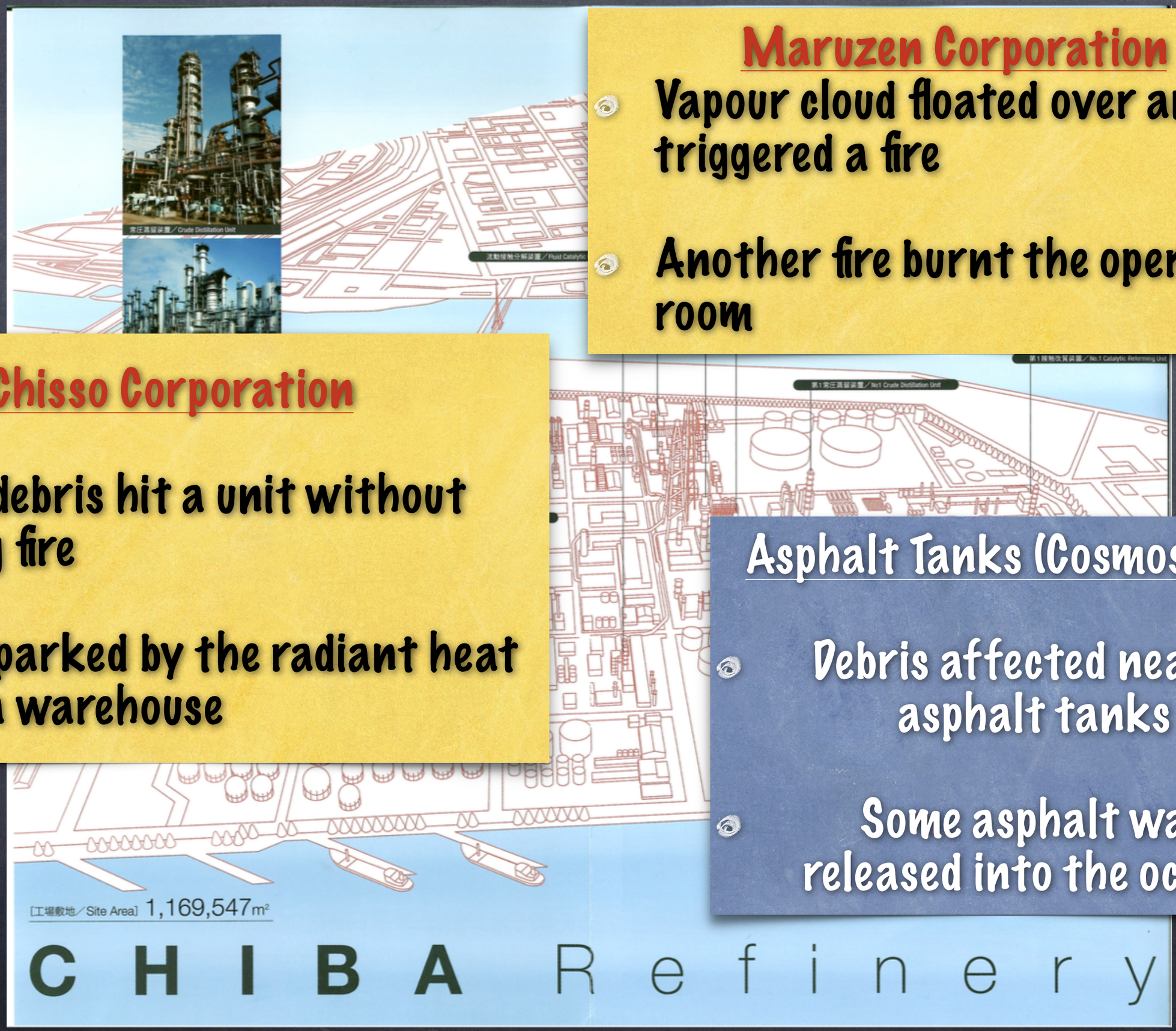
March 11 2011 15:47 HRS



COSMOS OIL REFINE[illegible]HIBA

March 11 2011　AFTER 15:47 HRS

March 31 2011



Maruzen Corporation

- Vapour cloud floated over and triggered a fire
- Another fire burnt the operator room

Chisso Corporation

- Flying debris hit a unit without causing fire
- A fire sparked by the radiant heat burnt a warehouse

Asphalt Tanks (Cosmos Oil)

- Debris affected nearby asphalt tanks
- Some asphalt was released into the ocean.

Earthquake (PGA=0.1 1 4g)

Broken braces of LPG Tank with water

Tsunami

Leg failure and Tank Collapse

Aftershock

Failure of connecting pipes and LPG release

Cloud dispersion and Ignition

Fire and Explosions

CASCADING EFFECTS

Fire spreads to Asphalt Plant

Damage at Chisso & Maruzen

EVACUATION

Barrier analysis

HAZARD 1 : EARTHQUAKE

Barriers	How did the barrier perform ?	Why did the barrier fail ?	How did the barrier affect the accident ?
Structural Barrier [design and operation of the tank]	For the first earthquake the braces failed and after the aftershock the legs failed which led to a complete collapse of the tank	The tank at the time earthquake struck was filled with water for maintenance purposes as a common practice the tank legs and braces were not designed to withstand the water load in case of a seismic shock. .	The failure of the tank caused pipes damage and connections breaking.
Human Barrier [checking and inspection]	On-site workers did check the tanks visually after the first shock. No actions were taken for safety assured as the tanks were still standing.	Careful inspection and likelihood of aftershock should have been taken in consideration.	Being not aware of the tank condition after the earthquake led the explosion after one hour.

Barrier analysis

HAZARD 2 : TSUNAMI			
Barriers	How did the barrier perform?	Why did the barrier fail ?	How did the barrier affect the accident ?
Structural Barrier [seawall]	The seawall managed to prevent the tsunami wave to overtop the building and protect the facility.		The seawall managed to prevent extensive damage that might have increased the loss and damage.

Barrier analysis

HAZARD 3: LPG LEAKAGE AND EXPLOSION			
Barriers	**How did the barrier perform?**	**Why did the barrier fail ?**	**How did the barrier affect the accident ?**
Safety valves	Safety valve was locked open due to repair works that led later on to LPG leakage	The valve was locked open not to get automatically shut by the air intruding the pipe during the repair.	The LPG leakage caused the initial explosion of tank 364 that led to further extensive damage later on.
Human barrier [safety workers]	Workers on site left the valve locked open in violation of the high pressure gas law. Despite the first shock of earthquake the valve was not shut.	Personnel were not well educated about hazards of sort. No adequate training or emergency drills for such large scale disasters had been taken.	

HAZARD 4 : CASCADING EVENTS & FURTHER DAMAGE

Barriers	How did the barrier perform ?	Why did the barrier fail ?	How did the barrier affect the accident ?
Secure connection system	Pipes were quite rigid so they broke at the collapse of the LPG tank and gas was released	Pipes material and connection were rigid and do not allow differential movement.	LPG was released due to the pipe break and valve opening
Human barrier	Workers on site left the valve locked open in violation of the high pressure gas law. Despite the first shock of earthquake the valve was not shut.	Personnel were not well educated about hazards of sort. No adequate training or emergency drills for such large scale disasters had been taken.	Uncontrollable LPG leakage that started the explosion
Tanks layout and spacing.	The spacing was between the adjacent units were insufficient as the fire spread to an adjacent asphalt Plant. Also units at Maruzen and Chisso were partially damaged.	The layout of the industrial complex has planning flaws. There is not provision of isolating explosion scenarios.	The cascading effect could have been controlled.
Firefighting team	Firefighting team arrived quite late due to traffic problems, they were not able to handle it alone, later on the municipal firefighting force joined and seaside firefighting as well	Lack of coordination between the site and the firefighting HQ, being under-prepared for a fire of such big magnitude and the significant distance from the fire site that caused the delay.	Fire was not well contained at first and further efforts were needed to contain the situation.

Barrier analysis

HAZARD 5 : ASPHALT RELEASE			
Barriers	How did the barrier perform?	Why did the barrier fail ?	How did the barrier affect the accident ?
Facility layout and complex and sectors isolation.	The Layout of the complex was quite tight that the rate of cascading events was quite high.	The debris hit so strong and reached quite far that even a proper layout and sectors isolating wouldn't have been very useful.	Asphalt release to the surrounding soil and ocean happened indicating a danger of contamination.

Root Cause Analysis

Tier	Causal factors	Root causes
Laws and regulations	No regulations pertinent to tank filling for maintenance	No definite regulation for maintenance
Senior management	1. Safety management plan and emergency drills were not well prepared 2. Evacuation, onsite and offsite, were not well prepared 3. There was no onsite firefighting force 4. The complex is tightly places so other nearby sites can easily get affected	No definitive NATECH Response Plan
management	1. Personnel in charge were not aware of the danger due to lack of information or training. 2. Firefighting force response and coordination was quite slow 3. and leadership were not well estimated from the beginning and had to be changed	
Supervision	1. No careful inspection or aftershock consideration have been taken 2. Valve was locked open in violation of laws 3. Water was left in the tank for long period *12 days* while the common practice is 2-3 days	Low Frequency of Regular Inspection
Workers actions	4. No careful inspection or aftershock consideration have been taken 5. Valve was left open despite the time workers had to shut it down after the earthquake	
Direct causes.	1. Earthquake 2. Aftershock 3. Safety valve locked open 4. Rigid pipes and connections.	

References:

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