# Stainless steel products for fire and explosion protection

## Existing applications in oil and gas

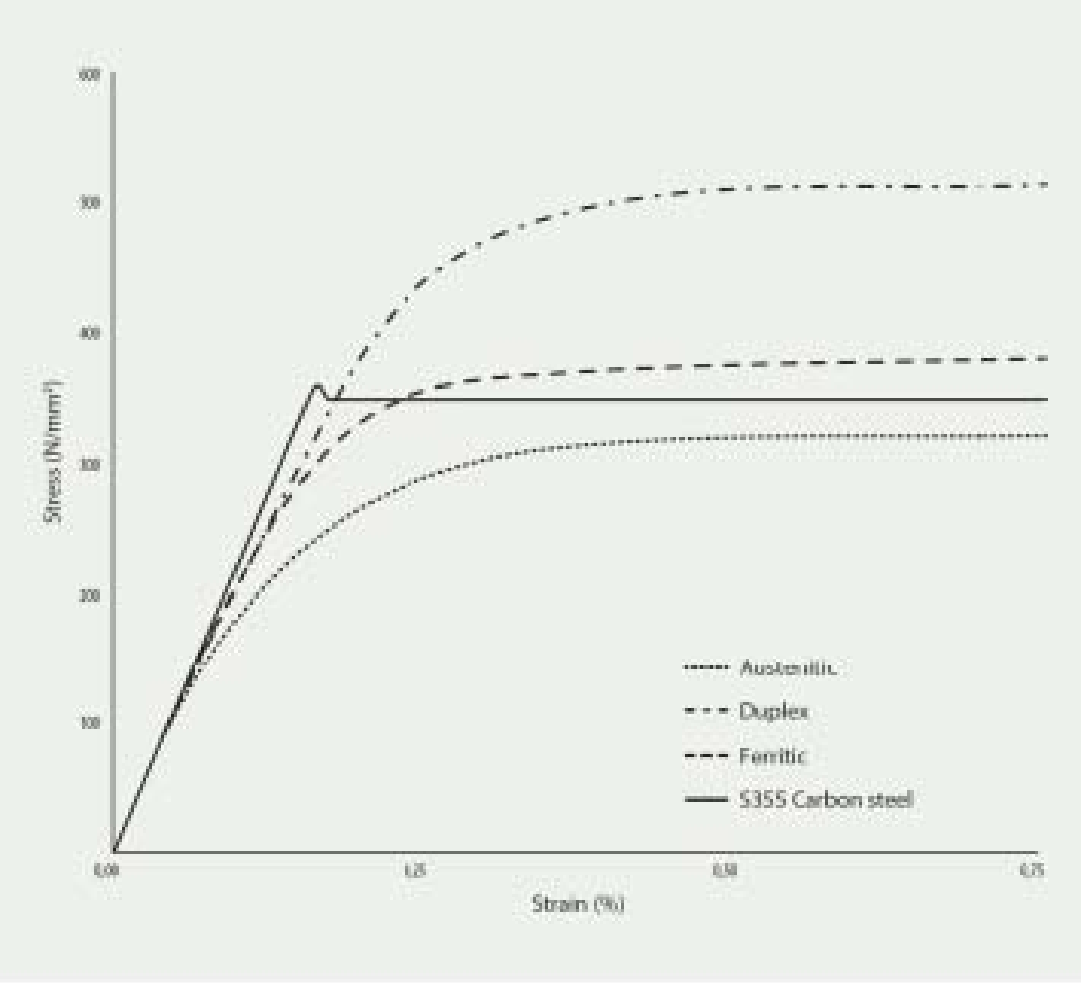
- Offshore blastwalls
- Explosion relief panels
- Offshore escape tunnels

## Future applications

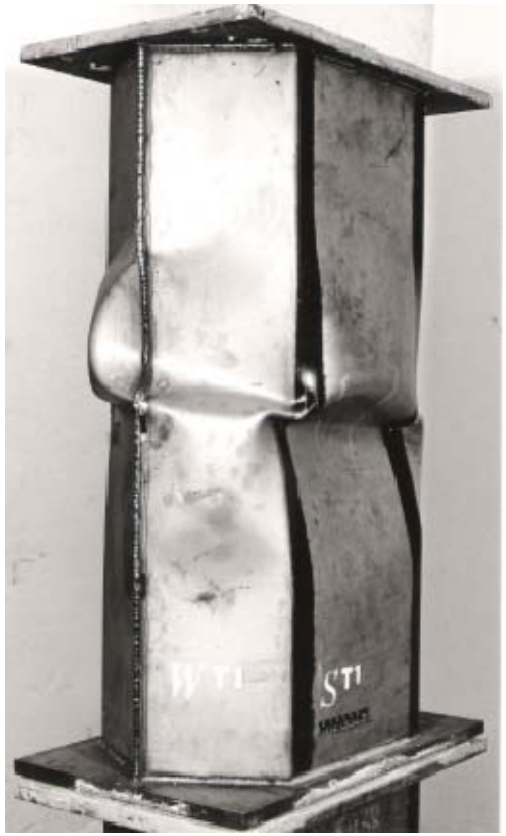
- prefabricated escape stairways for retrofitting to residential tower blocks
- Explosion and fire resistant containment systems Li-ion batteries for cars and domestic use

Acknowledgements:
GEXCON AS for dispersion and explosion simulations
Booth Industries Ltd (Bolton) for hardware pictures
Arup Advanced Technology Group for Non Linear FEA

# Stress-strain curves for stainless steel and carbon steel 0-0.75% strain (Euroinox guide)

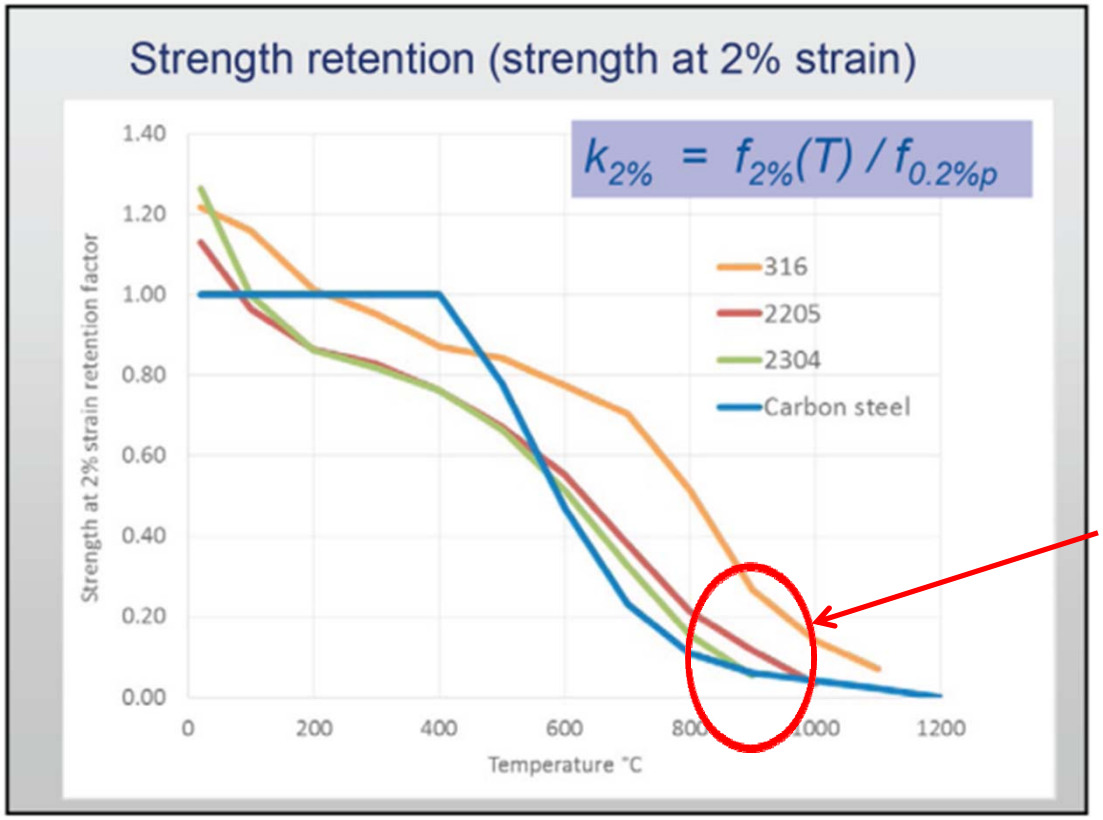


# Full scale crushing test on 4mm thick duplex stainless blastwall components shows ductile behaviour without rupture.



(Chapman Dowling - Imperial College 1991)

# Strength retention of carbon and stainless steels at elevated temperature.

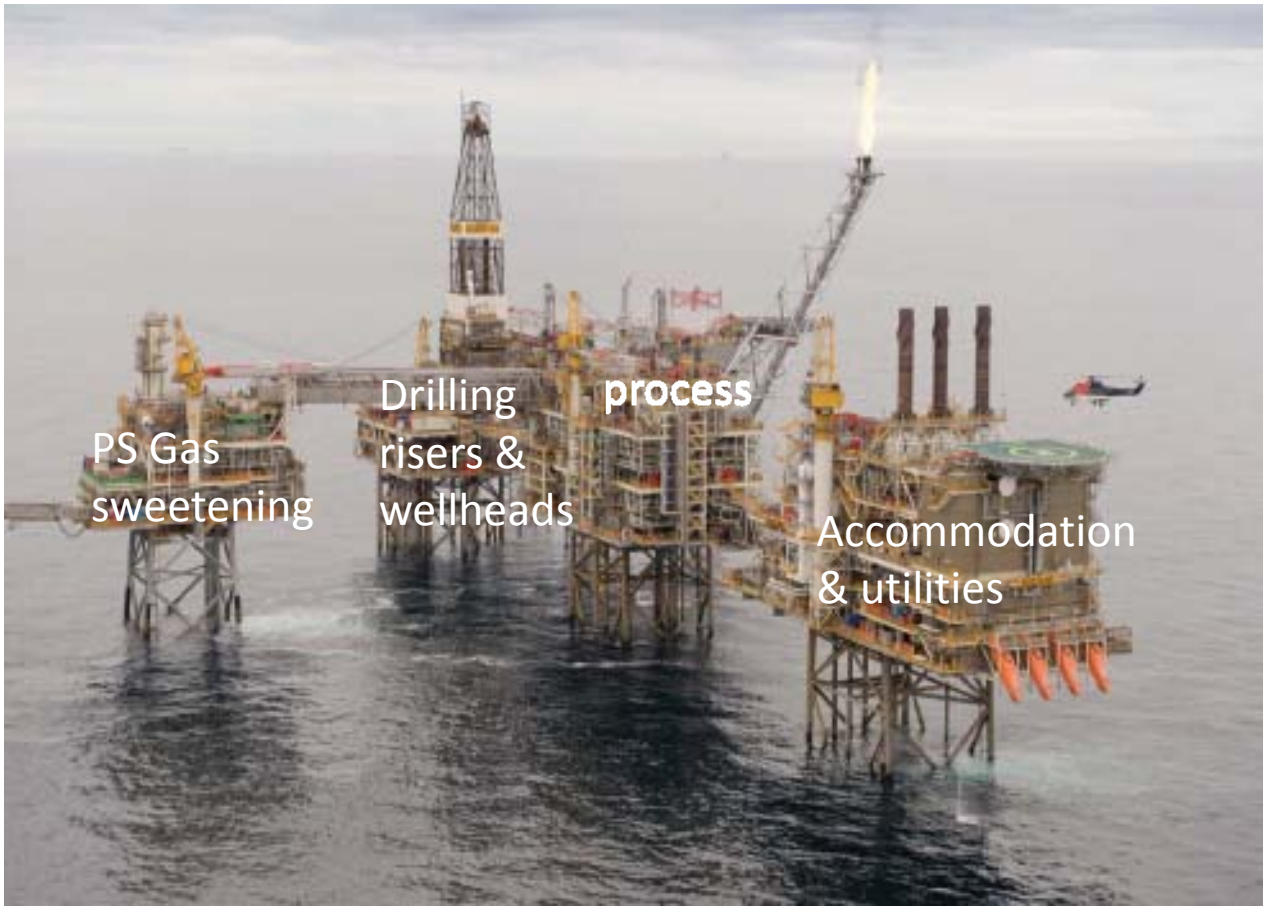



Zone of interest for the products presented as designs ensure that none are load-bearing during a fire

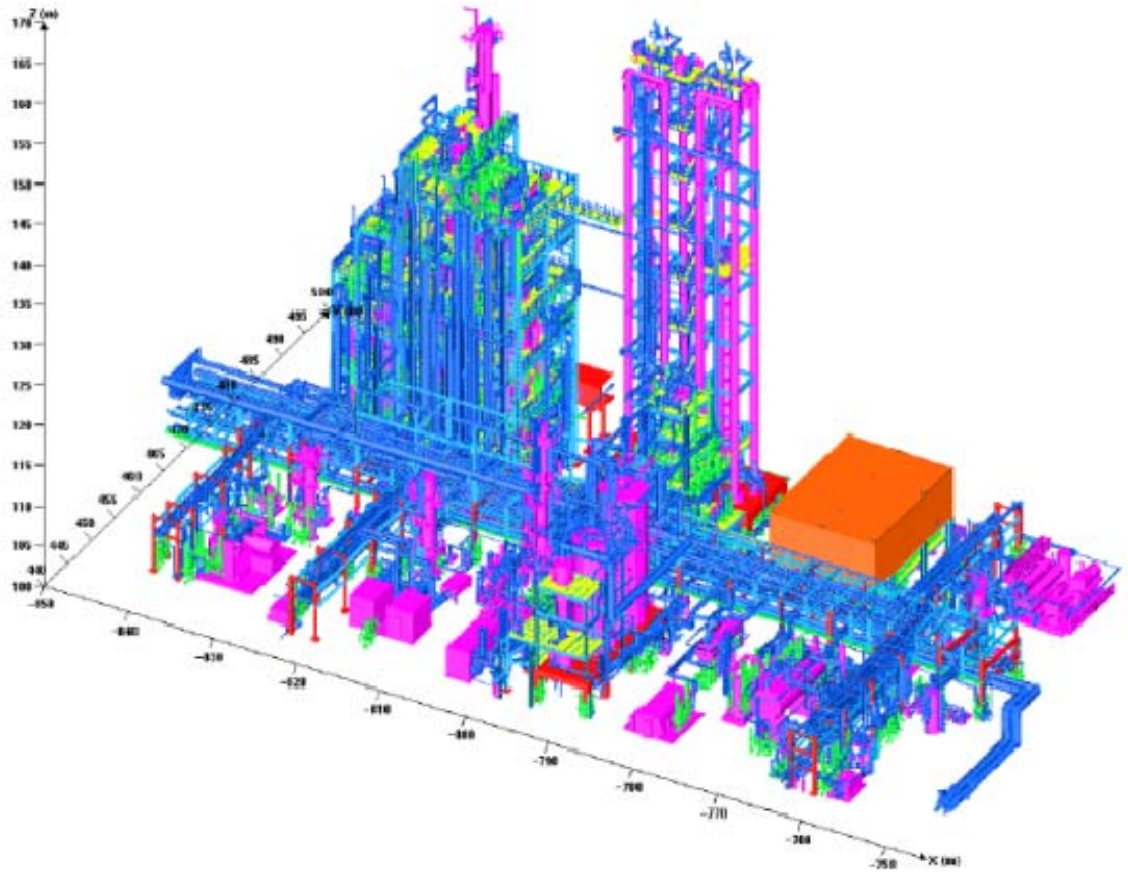
(Ref 3 Advances in the use of high strength carbon and stainless steels offshore, Fabig TM80 2014)

# Multiple fixed platforms - Buzzard development in UK North Sea,

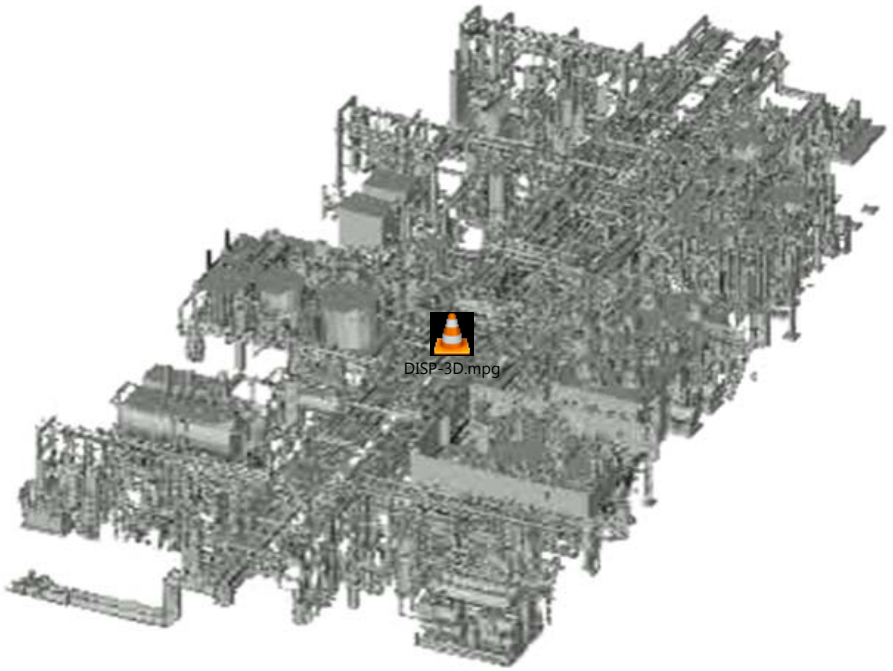
6 main blastwalls and much other cladding. All stainless steel



# Part of an onshore chemical plant: FLACS geometry model for explosion analysis

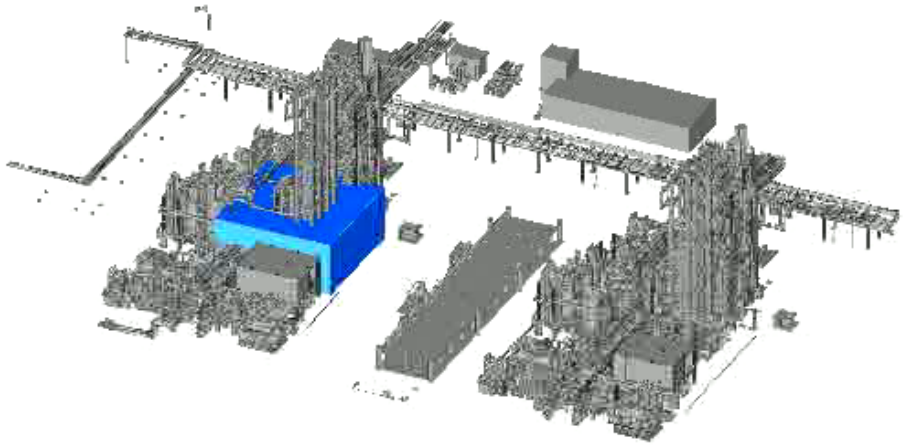


# Part of an onshore chemical plant: Animation of dispersion of a gas cloud



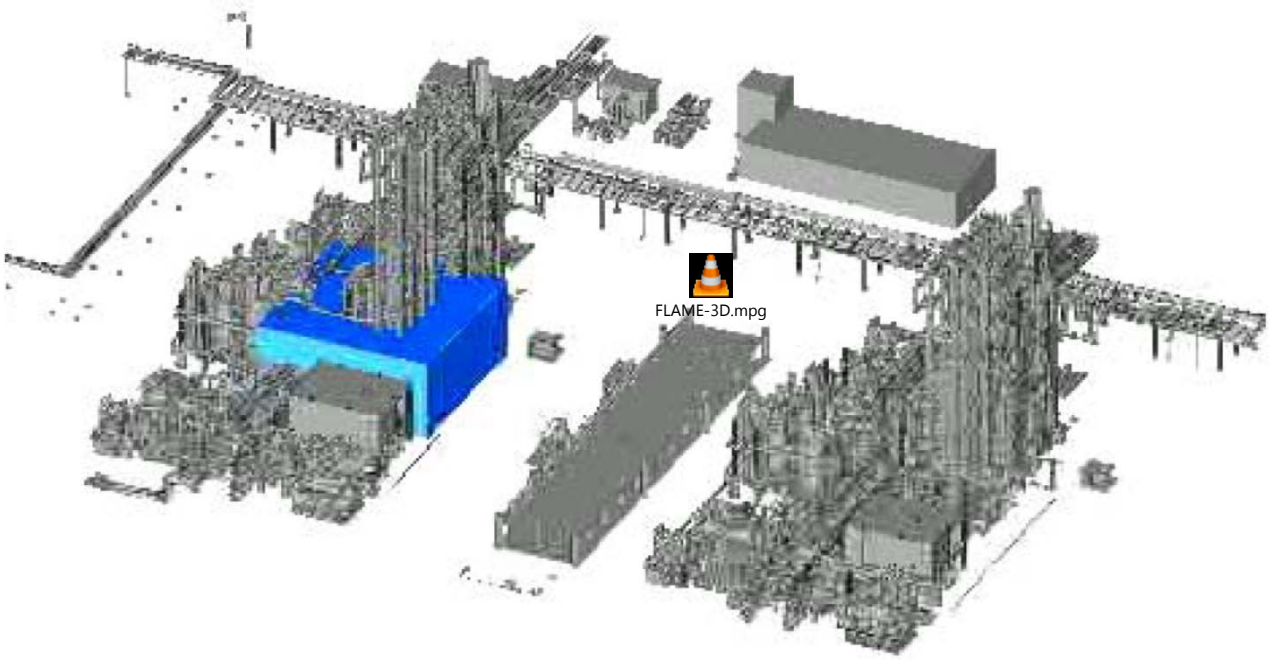

Job=361717. Var=ER (-). Time= 38.966 (s).
X=-847 : -731, Y=428 : 491, Z=101 : 107 m

# Part of an onshore chemical plant:
# Explosion simulations – assumed vapour cloud for study

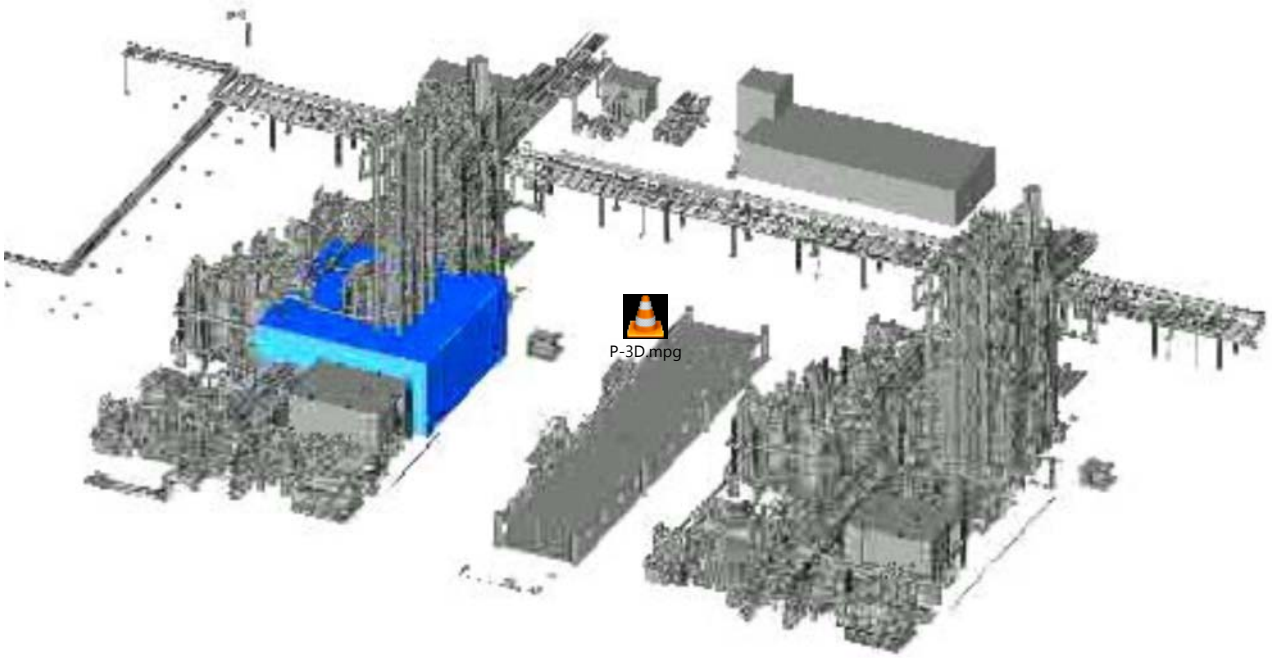


Job=100441. Var=ER (-). Time= 0.000 (s).
X=-896 : -704, Y=403 : 609, Z=100.5 : 147 m

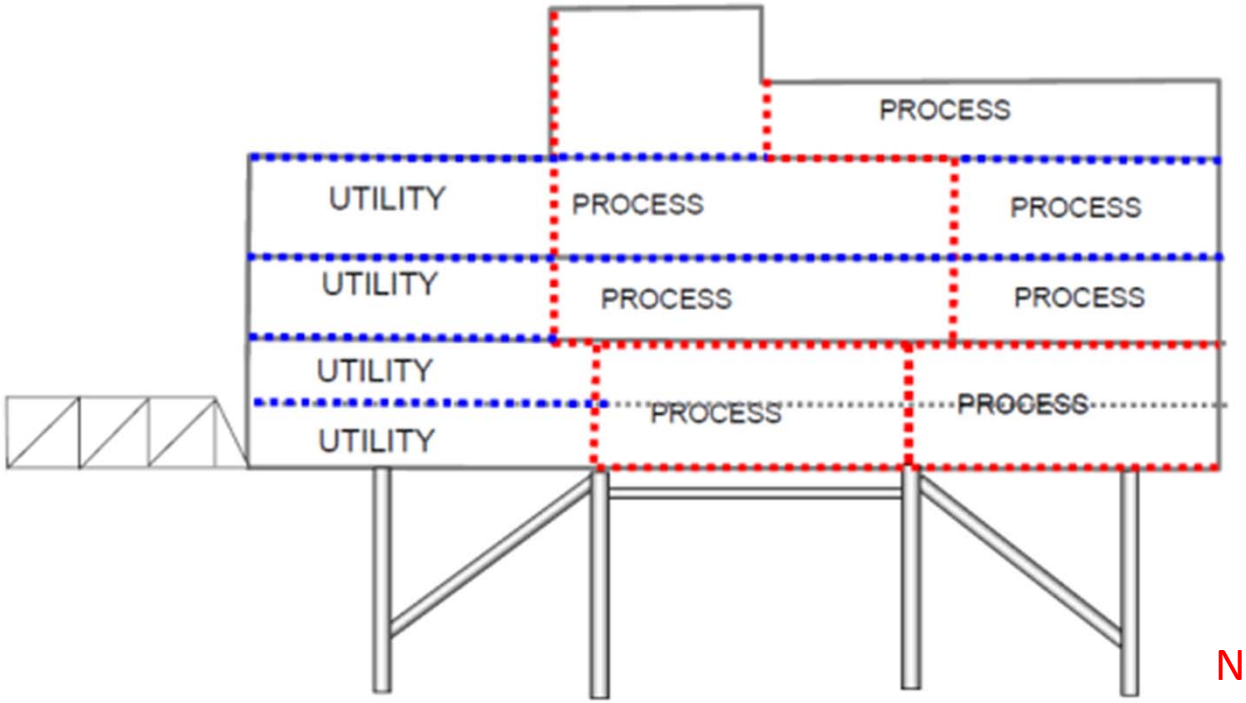
# Part of an onshore chemical plant: Explosion animation – flame growth



# Part of an onshore chemical plant: Pressure wave animation



# Positions of blast and fire barriers in a typical large process topsides



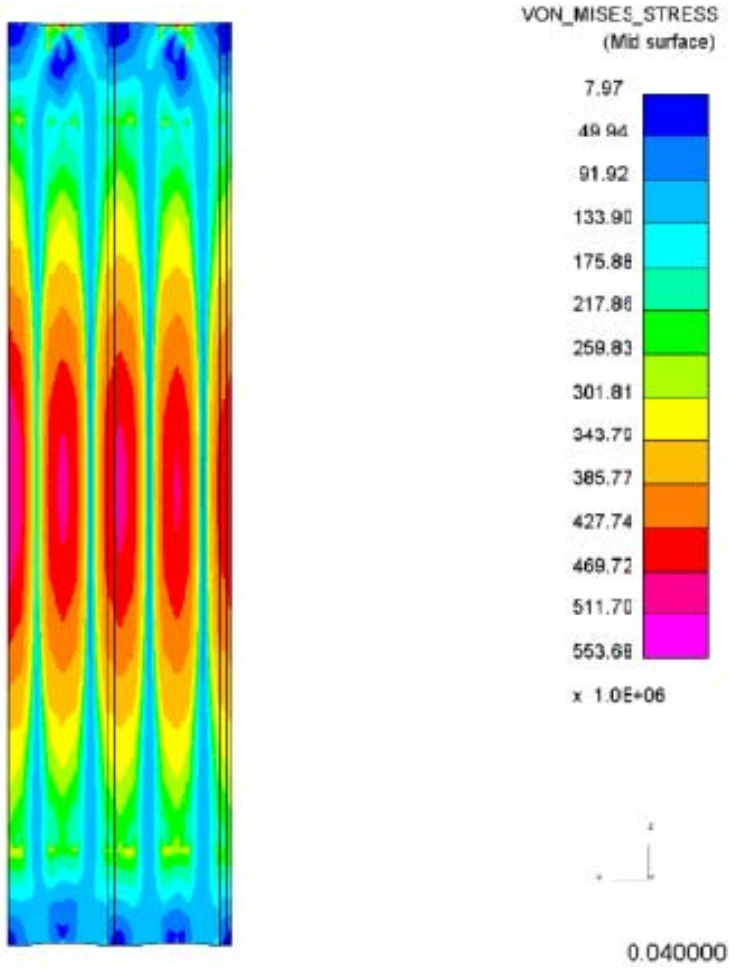

Note red barriers are blast and fire resistant

# Stainless steel blastwalls in an offshore module

Note, structural connection of stainless steel to carbon steel is by welding

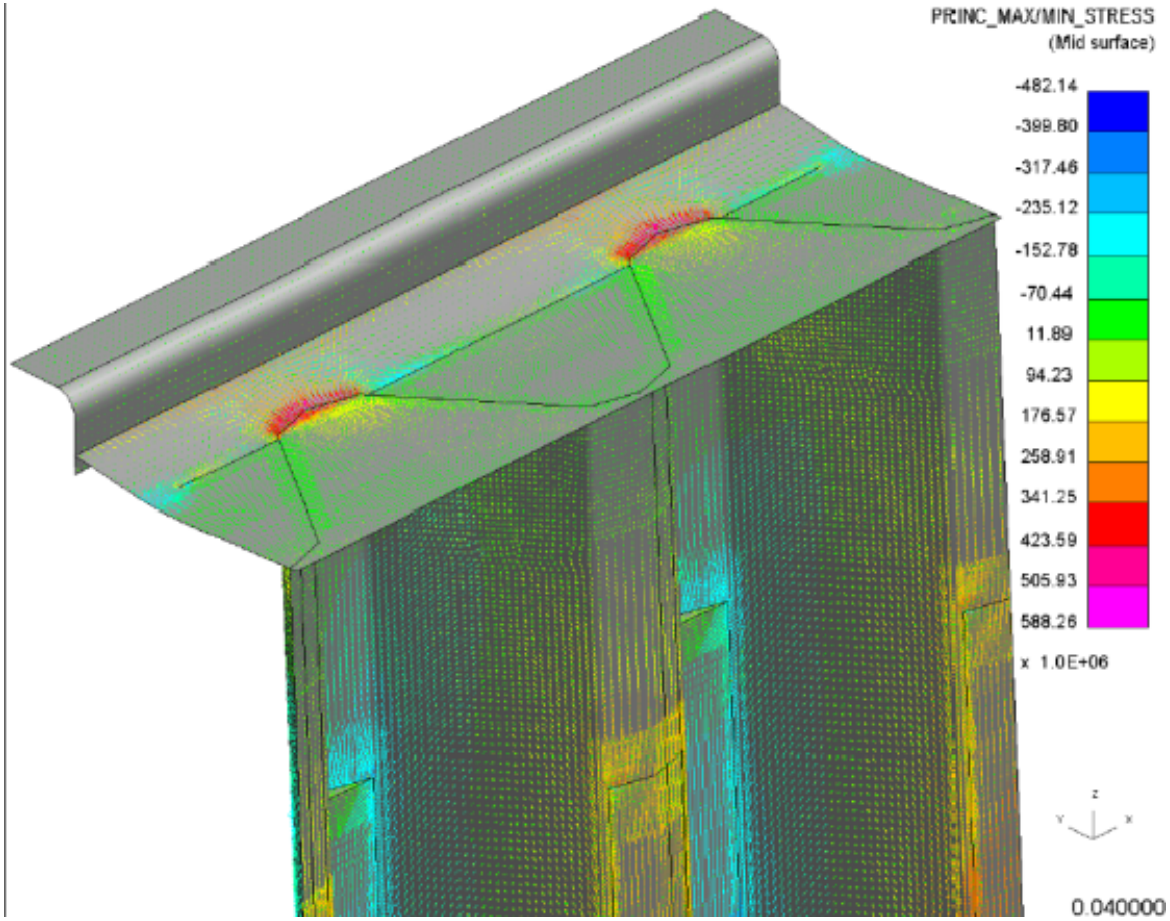
# LSDYNA model for a non-linear analysis of a 9m high wall, supported at top and bottom only

(Von-Mises Stress)



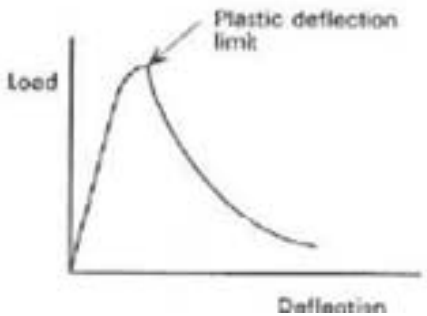
# Close-up of upper part showing grade S355 compliant top support and mesh refinement in NLFEA model

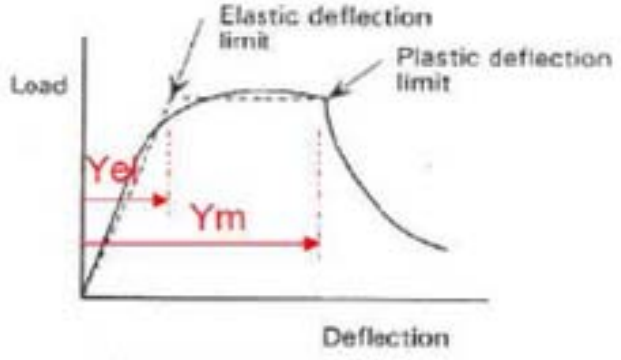
(principal stress)



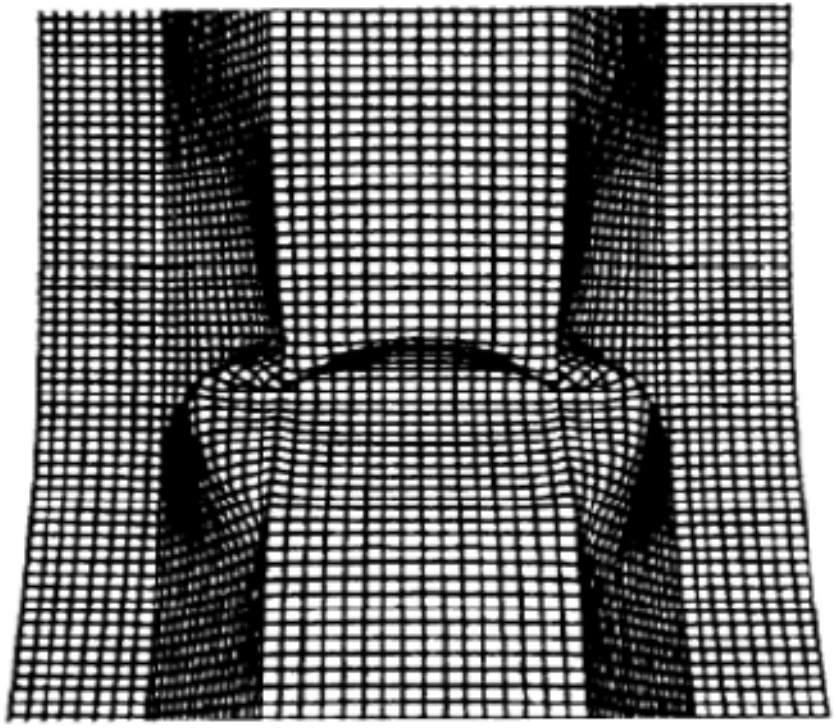
# Definition of elastic and ductile response behaviour of a structure

Ductility ratio = Ym / Yel



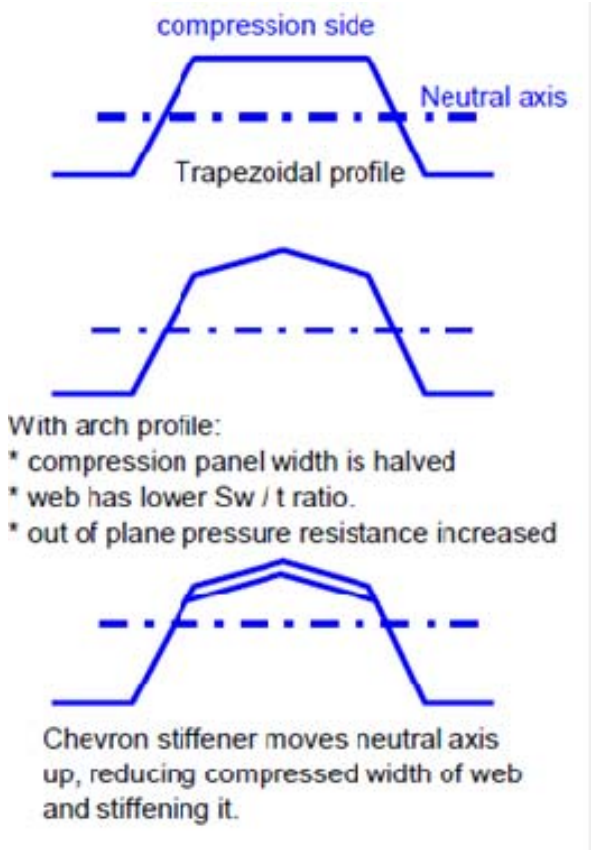



# Local buckling failure mode for normal trapezoidal corrugation with b/t ratio 60 (elastic response behaviour)



# Patented arch profile blastwall improves post-elastic buckling performance

Much used for stainless steel blastwalls



# **Arch profiles for 3 bar blastwalls destined for offshore Azerbaijan,** note fabricated panel on right

# Explosion relief panels (ERPs):

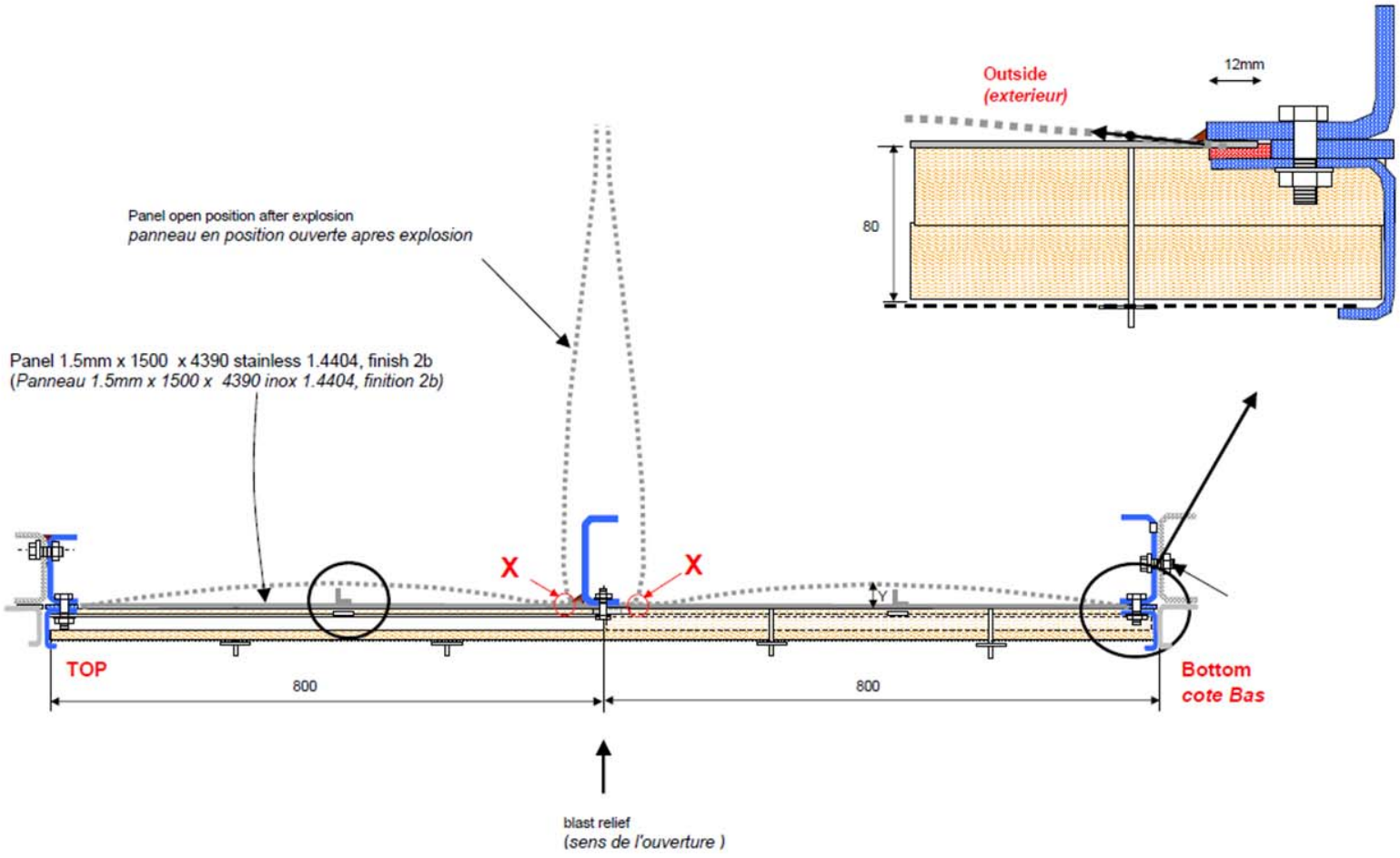
## Stainless steel explosion relief panels installed on a gas compressor building in France

# ERPs viewed from inside. Note, alu foil & chicken wire covered high density rockwool insulation for sound reduction & fire resistance.

# 7.2m long prefabricated roof cassettes for explosion relief of a gas compressor enclosure (UK)

# Transverse section through wall ERP

shows how they open in an explosion



# Explosion Relief panel before full scale explosion test.

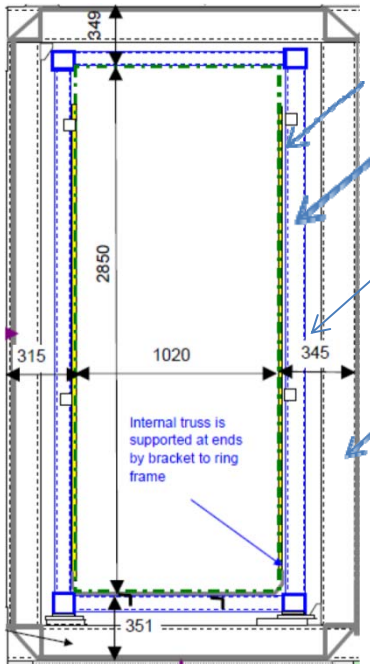
(and video of front view showing congested test module)

# Explosion Relief panel after explosion test to 0.5bar.

## And video of side view

# Offshore escape tunnels, type 1:

With type 1 overall strength comes from truss, insulated from SS outer carcass.




Inner liner (SS)

Ceramic fibre insulation

truss

Outer carcass is blast & fire resisting

Internal view showing liner

# Type 2 offshore escape tunnel on a 240m long FPSO:

Overall strength comes from SS outer carcass (stressed skin).
Internal truss is for carcass support to prevent sagging in jet fire after an explosion

Escape tunnel 2 – 3 bar resistance on inboard side

## Prefabricated Type 2 escape tunnel section

This FPSO example has extra width for internal control panels serving nearby external process equipment.

The ring frames at supports are thick-wall carbon steel RHS.

Note access door.

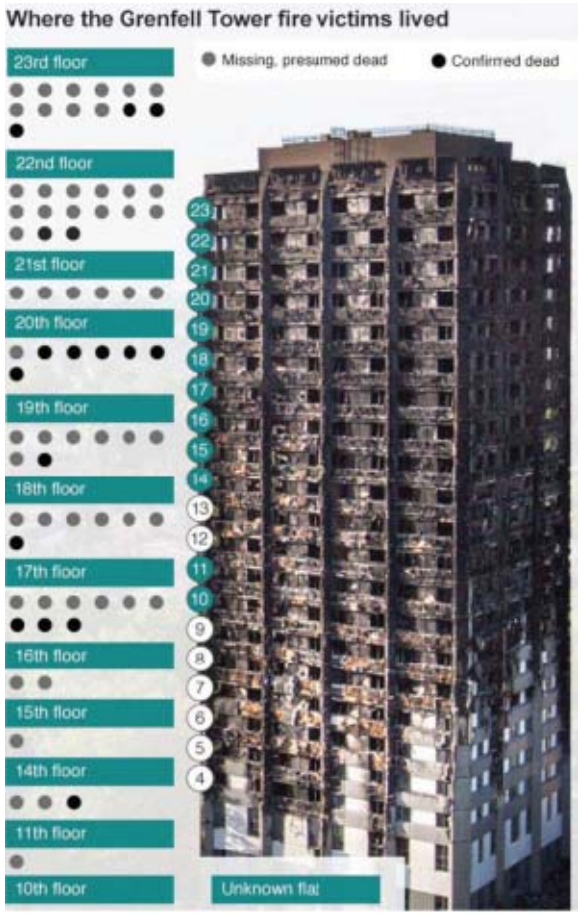
# New application for stainless steel in retrofit escape tower for residential tower blocks:

## This shows Grenfell tower, where the ~80 victims died (mostly in the upper floors)

What the fire rescue people said to BBC news 14-06-17:-

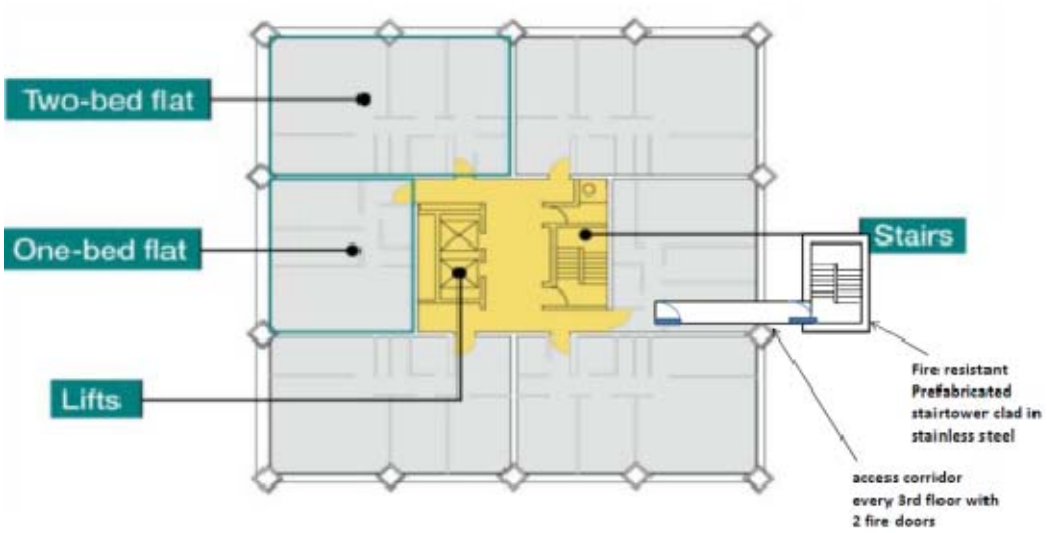
Time inside the building limited by use time of breathing apparatus in the smoke – filled stairway.

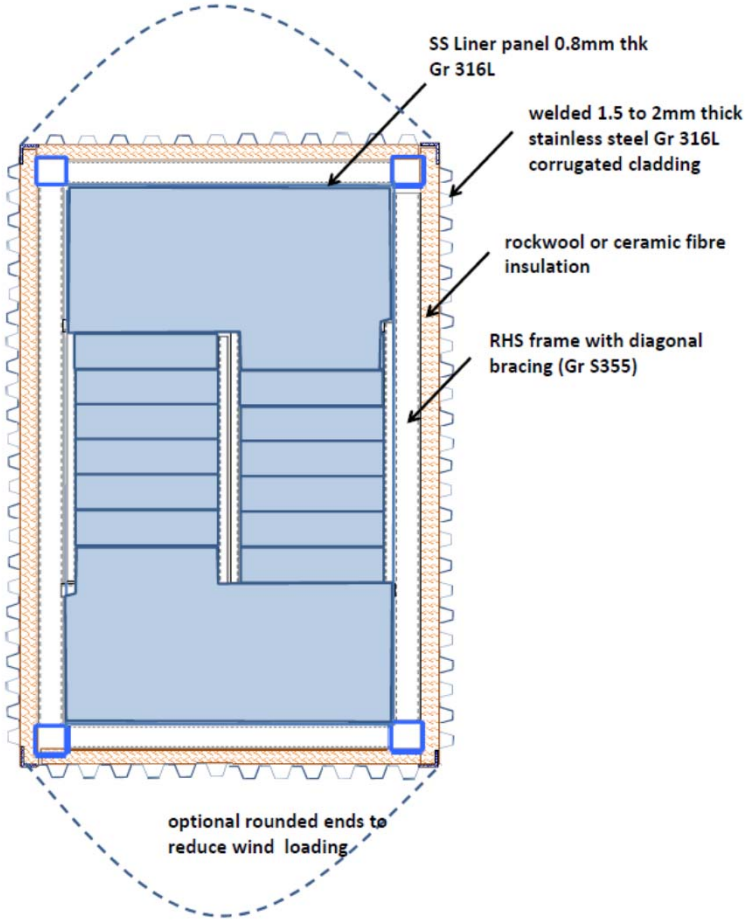
Difficult going up when escapees were coming down the stairs.




Ref 6/30/2017 London fire: A visual guide to what happened at Grenfell Tower - BBC News http://

# Retrofit escape tower - based on Type 1 offshore escape tunnel could improve escape possibilities.



# New application 2, lithium Ion battery containment for cars and domestic use: hazards of use

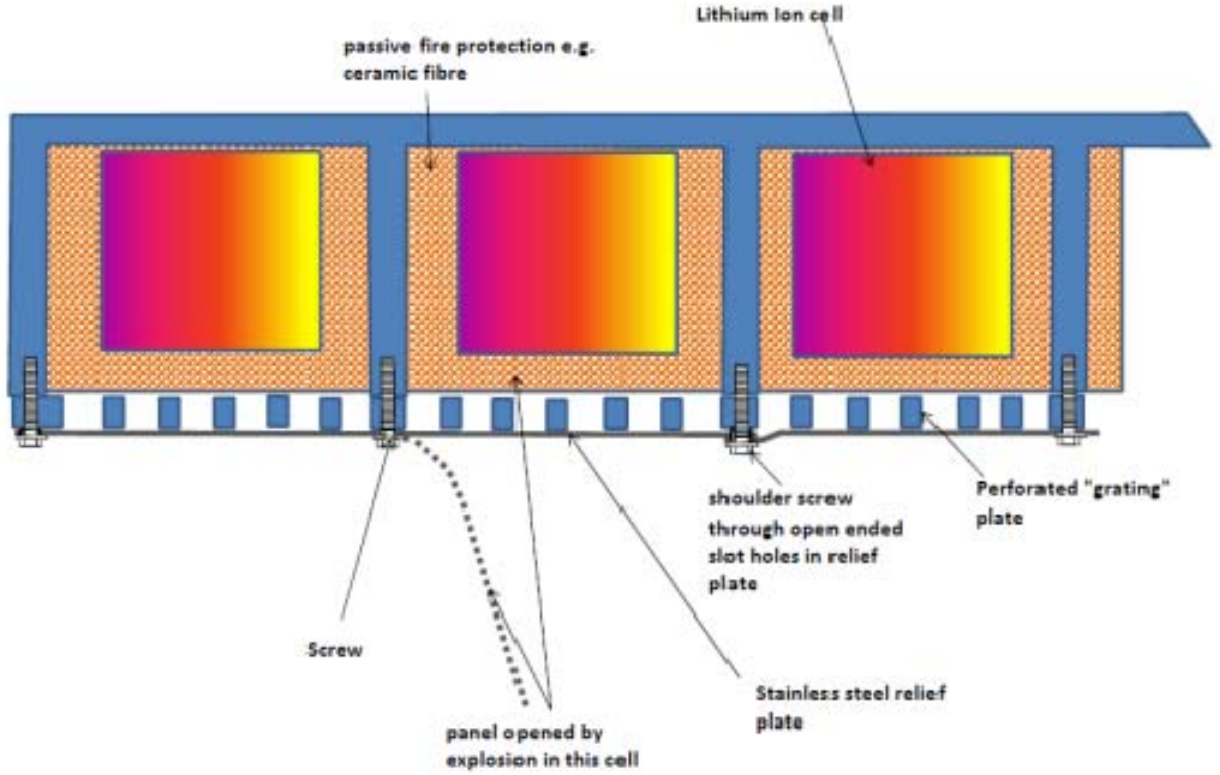
- Lithium ion batteries can burn/explode if physically damaged or heated.  More hazardous than other battery types.
- Can ignite accidentally due to control failures
- Once ignited cannot be extinguished in less than 30 mins – 1hr, needs 25tonnes of water.
- Can reignite or explode in the following 24 hours (problem for removal of a car after a crash?)
- Poisonous acrid smoke given off affects people nearby
- Difficult to cope with casualties in a burning wreck
- High voltage electrocution risk for rescue people
- Lack of experience or proper collated accident data available for training of emergency crew.

# Tesla S fire at a recharging station in Norway

There have been fatalities with electric vehicles (EV's) in accidents due to damage to battery containment.

# A potential solution, based on minimising risk and consequence

uses SS Relief panels, venting downwards, because battery is located just below vehicle occupants in EVs



# Battery containment function is to reduce consequence from a cell failure or severe crash

- Provides separation of cells,
- Explosion relief for internal explosion
- Resistance for fire and explosion in an adjacent cell.
- Insulation reduces risk of escalation from one cell to several cells and allows more structure distortion in a crash without cell damage.
- Perforated plate protects against impact from beneath battery set

# Conclusions

1. The strength, fire resistance and ductile capacity of stainless steels has made them extremely useful in explosion and fire resistant applications.
2. It will continue to be so for future large and small scale applications.
3. Fire and explosion protection needs to be backed up by an effective regulatory regime to make sure appropriate concepts are applied properly.