Risktec
RISKworld issue 2 autumn 2002 pg 4
the newsletter of risktec solutions limited

# Flameproofing...

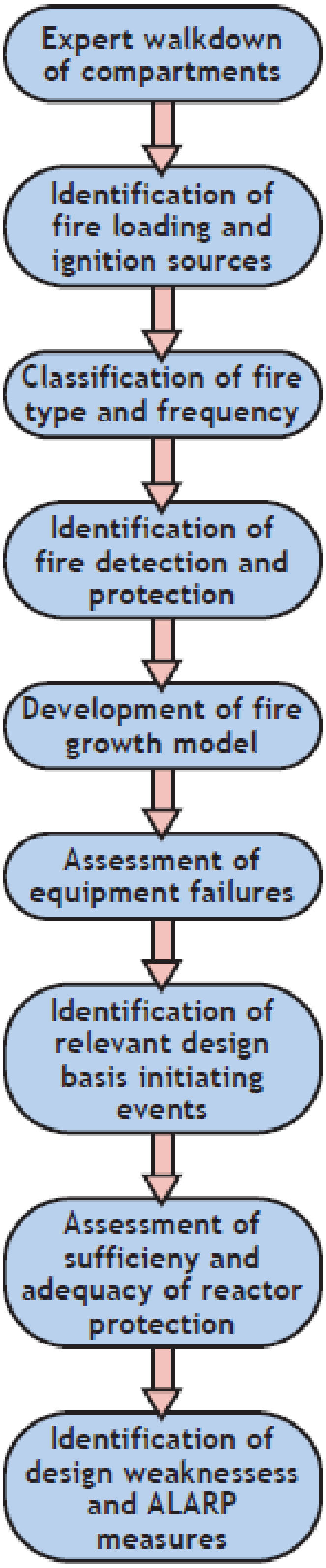


Figure 1

The prospect of a major fire onboard a nuclear submarine is almost unthinkable (see inset).

One approach to managing this potent hazard in multi-compartment spaces is to model the fire progression using computer codes based upon three dimensional computational fluid dynamics (CFD).

Unfortunately, this can be time consuming and expensive, and is only as good as the model definition. Moreover, the requirement to tie the fire modelling results into the safety justification for the reactor plant may be overshadowed by the effort associated with CFD. A more pragmatic and cost effective approach is outlined in Figure 1.

## Expert walkdown of compartments

The starting point for assessment is a physical or tabletop walkdown of compartments by suitably qualified and experienced operators, designers and fire experts. The initial purpose of this walkdown is:

- The creation of an equipment inventory
- The demarcation of each room or compartment into smaller zones (where necessary) to facilitate analysis of fire growth.

## Identification of fire loading and ignition sources

At the same time, the walkdown identifies equipment with the potential to act as an ignition source or as fuel, adding necessary detail in slower time by reference to authoritative fire data.

## Classification of fire type and frequency

The walkdown categorises potential fires according to both their likely size and type based on the sources of fuel and ignition present. An example of such a scheme is given in Table 1.

The likelihood of each fire is determined on a qualitative basis from which a quantitative value can be inferred (see, for example, Table 2).

Crucially, the results of this exercise are reviewed against relevant historical data to confirm their consistency with evidence available from operational experience.

## Generation of fire growth sequences

A fire growth model can now be developed that takes account of the detection and fire fighting capability within each local zone and/or compartment, including:

- First aid firefighting
- Fixed firefighting systems
- Compartment re-entry.

## What if the unthinkable happened . . .

Petty Officer Kelly should have been asleep in his bunk. Instead, at 4am, he found himself rubbing tired eyes, staring at a relay lying in pieces in front of the adjacent switchboard cabinet.

The repair would take him another half-an-hour, he thought, cursing. Oh well, at least he could look forward to an early breakfast.

His meandering thoughts were interrupted by a quiet hiss, coming from behind. Turning, his eyes fixed on a plume of mist issuing from a small bore pipe, drifting towards the turbo-generator switchboard. In the next instant, the vapour cloud exploded, flinging him across the compartment.

Lying on the floor, struggling to breathe, his thoughts danced from his complaining body to the prospect of the engulfing fire. The complete loss of electrical power would be bad enough for the dived submarine.

Even now, he imagined, the well-trained crew would be driving the crippled vessel to the surface and readying a team to attack the fire. If they failed to rescue the compartment, there were worse prospects ahead.

Although the nuclear reactor was designed to shutdown automatically on loss of power, its long-term safety depended on restoring electrical systems . . .

The resulting fire growth model is again reviewed against historical data to ensure that it remains realistic.

## Identification of design basis initiating events

From the validated fire growth model it is possible to identify those fire events that would lead to:

- A significant fire (e.g. type 1 or 2) where first aid fire fighting and fixed fire suppression systems fail, but the fire is ultimately brought under control by the re-entry team, hence restricting fire damage to a single local zone
- A major fire where none of the fire suppression methods succeed and the compartment is lost.

In both instances, it is assumed the integrity of any equipment contained within the affected local zone (for significant fire) or compartment (for major fire) is challenged. By making reasonable assumptions about equipment loss any given fire can be linked to one or more initiating events in the Reactor Plant Safety Justification (RPSJ).

## Assessment of sufficiency and adequacy of reactor protection

Having identified the relevant initiating events, the RPSJ's fault schedule may be used to determine which protective safe-guards may potentially be claimed, discarding those substantially affected by fire.

## Identification of design weaknesses and ALARP measures

Assessing the outcome against predefined design basis assessment criteria (such as the preferred number of safeguards, their degree of single failure tolerance) leads naturally to:

- Singling out potential design weaknesses with respect to fire
- Identifying where targeted use of detailed fire modelling such as CFD could be beneficial
- Deriving potential improvements for subsequent ALARP assessment, such as the removal or reduction of fire loading and ignition sources, introduction of automated fire suppression systems, the increasing of separation or segregation of vital safety systems
- Determining fire - related safety functional requirements (e.g. fire withstand) and operating constraints.

Table 1

| Fire Type | Description |
|---|---|
| 1 | **Minor fire,** such as oily rags, solid materials, pools of lubricating oils, paper. |
| 2 | **Minor electrical fire,** such as spark generated, overheating components, insulation material. |
| 3 | **Major fire,** such as gas or hyraulic oil mist ignition, characterised by a rapidly moving flame front, or an escalation from a type 1 or 2 fire. |
| 4 | **Explosive fire,** occurring within compartments, or spaces, used for the stowage of conventional explosives or propellants. |

Table 2

| Fire Frequency Band | Occurrence During Life of the Facility | Fire Frequency (/yr) |
|---|---|---|
| Frequent | Likely to occur repeatedly | >1 |
| Probable | Likely to occur from time to time | 0.3 |
| Occasional | Likely to occur once | $3 \times 10^{-2}$ |
| Remote | Unlikely to occur | $3 \times 10^{-3}$ |
| Improbable | Very unlikely to occur | $3 \times 10^{-4}$ |
| Highly Improbable | Extremely unlikely to occur | $3 \times 10^{-5}$ |
| Beyond Design Basis | Extremely unusual event and unlikely to occur | $3 \times 10^{-6}$ |
| Incredible | | $<10^{-6}$ |

## In conclusion

Although the development of this technique has been pioneered on nuclear submarines, in principle it offers an economic, modern standards approach to the fire assessment of any multi-compartment facility.


**UK Principal Office**
Wilderspool Park
Greenall's Avenue
Warrington WA4 6HL
United Kingdom
Tel +44 (0)1925 611200
Fax +44 (0)1925 611232

**Other UK Offices**
Aberdeen
Ashford
Edinburgh
Glasgow
London

**Middle East**
Dubai
Muscat

**North America**
Calgary
Houston

For further information, including office contact details, visit:
**www.risktec.co.uk**
or email:
**enquiries@risktec.co.uk**