UNITED KINGDOM USE OF SALALAH PORT, SULTANATE OF OMAN FOR THE MOVEMENTS OF MILITARY EXPLOSIVES

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Introduction

1. We in the UK have a requirement to conduct training in hot climates; such training cannot be carried out in the UK, we do not have the climatic conditions that would enable it. (Although the sun shines, it rarely gets above 30 C). Consequently we use overseas locations.

2. The UK has a long history with Oman; having supported the current Sultan during the Dhofar troubles on the late '60's – early '70's. The UK MOD has been using the Sultanate of Oman for RAF Flying Training for a number of years, operating from Thumrait air base. The location presents good climatic conditions to support hot weather flying; additionally there are large range areas, which cannot be found in UK, for the use of aircraft weapons instead of practice ammunition. We country also provides good opportunities for SF training.

3. There is one RAF exercise annually in Oman, with the explosives required provided by UK imported through the port of Salalah, at Raysut, in the South.
To move large quantities of ammunition and explosives to Oman, cost effectively, requires sealift. This inevitably means that we need to discharge the explosives cargo at Raysut, a civilian commercial port, in order for it to reach its destination. There is no explosive licensing scheme in place at Raysut. We are faced with the prospect of positioning quantities of explosives at a location that is not under military control and not experienced at handling military explosives.

Fig.1 Map of Oman

4. It is worth noting that even where commercial ports are licensed for explosives the consequence to the movement of explosives is a reduction in activities within IBD. At Salalah, although a 100m cordon is set up for each movement of explosives, this is a security requirement; there was no concept of the potential hazard from large quantities of fragmenting military ammunition.

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5. When moving explosives through overseas ports we have a duty to ensure that we are not ignoring our safety standards just because it is out of sight and therefore out of mind. In addition to the duty of care, there is Public and Political opinion to contend with. This might well be particularly damaging should we have an incident, and were seen to be ignoring safety standards, just because we are abroad and the host nation had none.

6. Consequently the UK has taken the stance that we must take account of the ports to be used, review their existing arrangements, and compare them to the standards we would expect in the UK. In fact we are mandated to do so by our Secretary of States Health and Safety Policy. We must observe either the UK or Host Nations standards, which ever are the more stringent, where ever practicable. This led to two members of the UK MOD Defence Ordnance Safety Group carrying out a survey of the arrangements at Salalah Port, with a view to determining whether it could be licensed if this were in UK, and if not determine what mitigation measures we can take to make the residual risks acceptable, during Mar 2009. This survey coincided with an import of explosives to support the 2009 annual RAF exercise in Oman.

Salalah Port

Fig. 2 SALALAH PORT

7. Salalah is the capital city of the Dhofar region, in the south of the Sultanate of Oman. The port is located some 15 Km to the west of the city in the district of Raysut. It was originally a small fishing harbour that has been developed into a major commercial port.

8. The Port of Salalah is a major commercial transhipment hub for the West Central Asia Region. It is situated at the major East-West shipping lanes, making it a strategic location in the Indian Ocean Rim and caters to some of the world's largest ocean going vessels. It is Oman's largest port. Managed by APM Terminals the port is a made up of two distinct areas;

a Container Terminal with 6 berths of up to18m depth; and a General Cargo Terminal of 12 berths of up to 16m depth. The preferred berth for explosives shipments is in the General Cargo Terminal, Berth 21.

9. It operates 24 hours a day, seven days a week, divided in day and night shifts, employing approximately 1700 people across all its activities. However, night work is predominantly in the container terminal. There is very little work in the GCT at night.

10. Development and expansion of both terminals is ongoing. Today the capacity of the container terminal is 4.5 million TEU. A tender for detailed design of Terminal 2, which has been launched, will add 1350 meters to the existing 2,205 meters linear quay. There are also plans to expand the GCT.

11. Security at the port is two fold, the Royal Oman Police provide an armed presence and the port also provides their own security organisation. Movements of explosives are under ROP escort and conducted after 23:00 hrs.

12. Fire cover is a single aged fire tender at the port with back up provide from Raysut Fire Station some 6 km away. Fire hydrants are fitted to the quay sides, but can, and often, have access to them blocked. There are three tugs with water monitors that can provide a fire fighting capability. Fire cover is not good, and the awareness of the likely effects from military munitions with blast and fragmentation hazards is minimal.

13. EOD cover is provided by the Royal Army of Oman from the ammunition depot at Adownib. This is located about 30 mins away to the west. However, the duty personnel live in Salalah; they would need to be called out from home, and transit past the port to get to Adownib.

UK Hazards

14. The survey was timed to coincide with an import of explosives into Oman for Exercise Magic Carpet 09. The total NEQ for discharge in support of Exercise Magic Carpet was 8,531 Kg, of which approximately 6,000 Kg was HD1.1, primarily Mk 20 Aircraft Bombs with RDX/TNT filling and an NEQ of 170 Kg each, which have blast and fragmentation hazards. However, the total NEQ of the vessel was 30,585 Kg. This was because the vessel was also carrying explosives destined for discharge in Mombasa for the routine re-supply of the British Army Training Unit Kenya (BATUK). The majority of the explosives for Kenya consisted of 105mm artillery ammunition, in excess of 19,000 Kg HD1.1. This, once again poses a potential blast and primary fragmentation hazard. (It is customary to maximise the available cargo space on vessels and this will include explosives destined for a number of ports).

15. If this activity was being undertaken in UK it would require a port with an explosives licence. Using the port quantity distances of $16.7Q^{1/3}$ for determining Inhabited Building Distance (IBD), a separation distance of 520m would be required between the explosives and any occupied facilities that were not involved with the explosives handling. We would require this area to be controlled so as to prevent any non involved people entering it without authority. At Salalah there is not the level of control for the IBD generated by the explosives NEQ that would be expected in UK. This, potentially, places a number of non involved people at risk.

Exposed Sites at Risk

16. Salalah Port has two distinct areas within the boundary, the Container Terminal and the General Cargo Terminal. Outside the boundary the principle area of concern is to the South side where there is an area of accommodation and the Port Control.

17. The Container Terminal is principally used for large container vessels. Vessels with UK Military Explosives embarked are usually RoRo ships that will berth in the General Cargo Terminal. Berth 21 is the usual berth.

18. The Container Terminal is adjacent to the Port Administration Offices; customs sheds and represents the areas of highest activity. It is in excess of 1400m from Berth 21 to the Port Administration Offices and there is no direct line of sight.

Activity in the Container Terminal is high but does not involve a lot of people exposed in the open. Vessels and containers will provide a high degree of protection from fragments that may originate from a vessel on Berth 21. The distance to the nearest point in the Container Terminal is in excess of 750m; Blast over pressure is not expected to be above 3.5 kPa, and more commonly, in the region of 2.5 – 3.1 kPa. Therefore the hazard to people in the open from blast is not expected to result in fatalities or serious injury.

Fig.3 View North to Container Terminal

19. The probability of fatality from fragmentation is between 1:10 and 1: 100. This is high for members of the general public; but the modelling has assumed no traversing to afford protection. Some protection will be offered from moored vessels and ISO containers which will preclude line of sight to many areas. There is a high degree of activity based around the Port Administration and Customs Buildings. Most of these people are indoors for the majority of the time; this will provide a high degree of protection but is not an area of activity that can be controlled by the UK MOD.

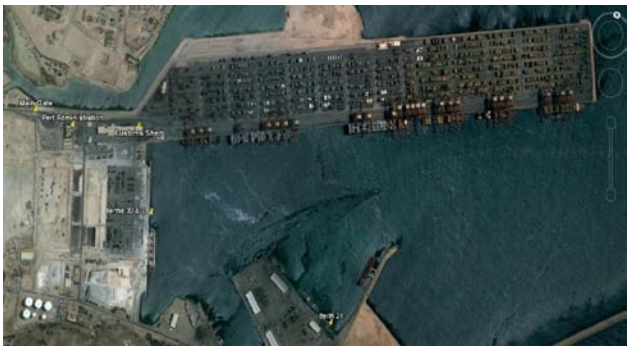


Fig. 4 Salalah Port Container Terminal

Fig. 5 GCT & EXPOSED SITES TO SOUTH

20. The General Cargo Terminal (GCT) is where most of the activity involving the presence of people takes place. There is a mix of containers and break bulk cargo, with most being break bulk. However, although there is good dock side lighting allowing night time work; it is not a regular activity. On the terminal there are a 5 x large span warehouses. Two have minimal occupancy, being used for the storage of bulk cement powder and cables respectively; they are normally only occupied when vessels are alongside and embarking or disembarking associated cargo. It would be expected that anyone in the cable warehouse, at 35m from Berth 21, would be fatalities in the event of an explosion involving the total HD1.1 cargo. The cement warehouse is located approximately 85m from the closest point to the explosives. A high level of fatalities would be expected here as well. Both warehouses would be expected to suffer total demolition or major structural damage. There would also be the probability of projected secondary debris from the cable warehouse.

Fig.6 General Cargo Terminal

21. On the south east aspect of the GCT is a warehouse used by DynCorps. This has its own secure compound with numerous ISO containers outside possibly indicating that there is a degree of activity in the open rather than inside the warehouse; but was not being accessed during the site survey. It would be expected that in the event of a major HD1.1 explosion on a vessel at Berth 21 this would also be approaching total demolition. Any people inside would be at risk from the building collapsing.

22. The other two buildings are a mix of small workshops and a café/shop. This latter facility is open 24/7 with a small permanent presence of staff, 3-5 people. Structurally they are all similar, concrete block work with external render and single glazed windows. There is seating for in excess of 30 people in the café. The café and shop is used by a variety of

people, including fishermen, crew and owners of private vessels in the marina, crew from visiting ships and port workers. Access to this area is unrestricted to anyone who has a permit to enter the port. In the event of a 30,000Kg HD1.1 explosion at Berth 21 it is anticipated that these workshops and the café/shop would be damaged approaching total demolition. People inside would be at risk of death or serious injury from the debris. Probability of fatality for people in the open would be high.

23. To the west side of the GCT area is a marina with access to private craft as well as fishing vessels and small patrol boats of the Royal Oman Navy. Access here is unrestricted, and there is no recognition that an Inhabited Building Distance (IBD) driven by 30,000 Kg HD 1.1 @16.7$Q^{1/3}$ will extend to 520m, encompassing most of the marina area.

Fig.7 View of Marina & Warehouse, Café/Shop

24. On the south side of the GCT are the administration offices and other support services. During normal working hours this is a busy area with port staff, customs and handling agents present. At night time these are generally unoccupied, or where staff are required at low levels of manning. The GCT administration offices are just outside IBD at 540m from a vessel on Berth 21.

25. Within the port boundary the principle areas of concern are the café/shop and the marina; there is uncontrolled access to both these (uncontrolled in so far as once you have a permit to be inside the port then you are free to access these areas with no further control). The Port Control Room is also an exposed site situated to the south of the GCT. It does not have a large number of people but is essential to the port operations. It is located on a headland and in direct line of sight from Berth 21.

Fig.8 View from Berth 21 to Port Control

26. The separation distance is 533m to the Port Control Room so from the risk of blast, it is not expected to suffer major structural damage, and anyone in the open would not be expected to be killed or to suffer serious injury. The fragmentation model would indicate that there is a 1:10 probability of a fatality; this is related to persons in the open. Berthing and disembarkation take place in the evening and at night respectively; the numbers of duty people expected to be present is approximately 5.

27. Shown below are the Probability of Fatality contours, with the probability set at 1, for 30,000 Kg HD 1.1 for people in the open and buildings. This is for the vessel untraversed and for both blast and fragmentation models. However, it must be borne in mind that this movement only takes place once annually; therefore the probability of an initiating event is very low, the initiating frequency is 10^{-8} for all initiating events.

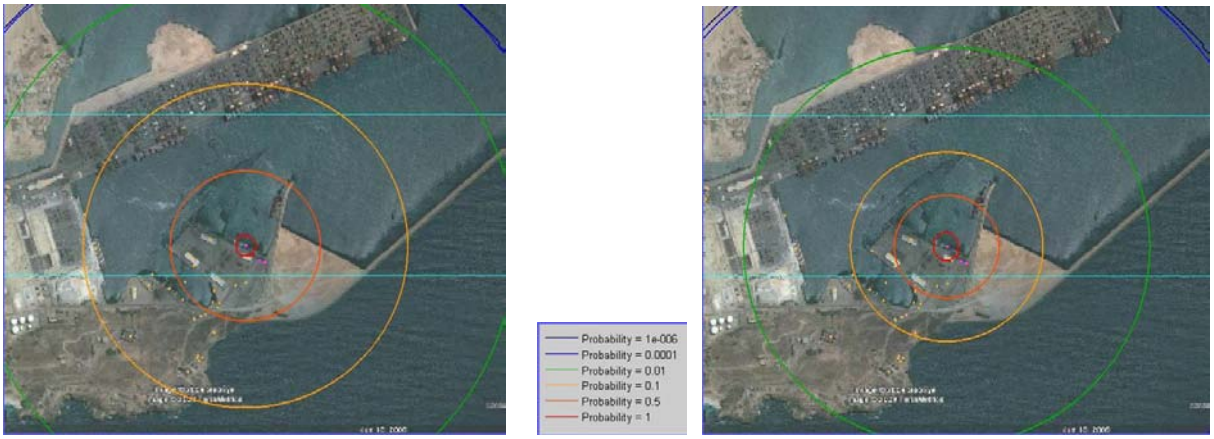


Fig.9 Conditional Probability of Fatality 30,000 Kg HD1.1 Persons in Open & Persons in Buildings

28. To the south of the Port Control Building, and outside the port perimeter fence is an area of accommodation. There is a single accommodation block constructed around a square, is concrete block and render and is 3 storeys high. Each room has a single window, double glazed. The roof is flat concrete with access for the occupants. There appear to be 84 individual accommodation units within this block. There is a second block under construction some distance further to the west.

29. Other accomodation units are single storey concrete block with sloping roof of profiled steel sheet. The terrain prevented line of sight from most of the accomodation and Berth 21. The only line of sight issue was to the north and east walls of the single storey accomodation units near the Port Control Building.

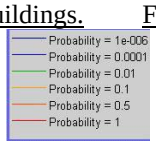
Figs. 10 & 11 Accomodation units

30. These accomodation units are located 730m from Berth 21 for the closest unit and 830m for the closest point of the 3 storey block. These distances place them outside of the $22.2Q^{1/3}$ required for storage IBD, and well outside of the $16.7Q^{1/3}$ required for ports licensing. Blast is not anticipated as causing a significant hazard; it is not anticipated that there would be any fatalities or serious injuries from blast alone.

31. Initial modelling indicated that there would be a high probability of fatalities in the accomodation areas, 1:10. This was particularly so for the evening/night time. Numbers of people present are expected to be higher than day time. However, due to the limitations in the modelling the exposed sites were seeing fragmentation that in reality would not be there; the rising terrain placed the accomodation out of line of sight from Berth 21 and would prevent low angle fragments from reaching that area. Accepting that the terrian provides effective traversing and thereby preventing low angle fragmentation, the model was run with the assumption that Berth 21 was traversed. This results a better modelling of the hazard and changes the probability of fatality to 1:100 for persons in the open. But it does come with a warning, the model assumes a conventional form of traversing close to the PES, not rising terrain some 400m away.

Fig.12 Weapon Fragments Persons in Buildings.

Fig.13 Weapon Fragments Person in the Open,



32. The contour plots above show a doughnut effect, this is believed to be due to the traversing intercepting the low angle fragments and the lobbed fragments subsequently falling in a ring around the explosion site; those close in to the exterior side of the traverse being afforded greater protection than people further out, for certain distances. Although the contour plots show a full circle, the traversing effect, here, is only applicable to the area from approximately 190^0 to 250^0 from Berth 21 and sheltered by the rising terrain. All other exposed sites have line of sight and are at risk from low angle high velocity fragments and debris.

33. Under UK regulations and with the current arrangements at Salalah an explosives licence for 30,000 Kg HD1.1 would not be issued; therefore it would not be permissible to disembark explosives. Using the ESTC Ports Model and assuming that activity was being carried out as normal, with nothing more than the 100m security cordon in place, it is anticipated that a 30,000 Kg HD1.1 explosion would result in approximately 90 fatalities. Overall the risks fall into the Broadly Acceptable region, however as we licence to consequence and not purely risk, then this would be an intolerable consequence.

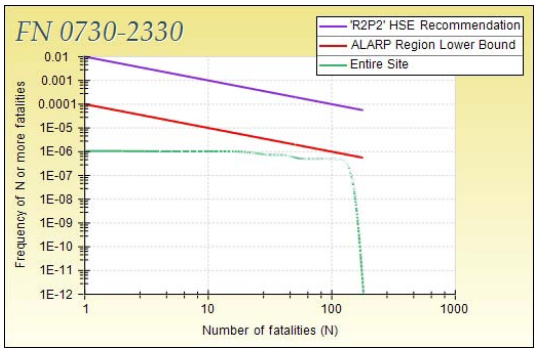


Fig.14 FN Curve Berthed 07:00 – 23:30

34. To put it into perspective, the 2006 Nimrod explosion in Afghanistan killed 14 servicemen. This resulted in the MOD being subject to a high degree of scrutiny by the press and public. A public enquiry has found the MOD failing in a number of areas. If an explosion occurred whilst discharging explosives at a port for which there was no explosives license, and it killed a large number of civilian personnel, this would probably not be tolerated by the public or our political masters, particularly so if it was demonstrated that we had made no attempt to assess the operating conditions and determine what mitigation could be taken.

35. To mitigate the potential consequences we have issued an instruction that places restrictions on the movement of explosives through Salalah Port. We have no authority to impose an explosives licence with operating conditions on the Omani's, so have to look at what actions are within our control.

36. Vessels carrying explosives for exercises in Oman are normally under MOD charter, so we are able to direct their movements. We have restricted their entry into Salalah Port to be outside of normal working hours, and as close to disembarkation time as possible. The ROP will not allow the explosives to move on the roads until after 23:30, so discharge can commence at about 22:00. There is to be no dwell time in the port if the vessel is carrying explosive for other destinations.

37. Berthing as close to 22:00 and discharging straight away reduces the potential number of employees that will be present at the GCT. The vast majority of fatalities will be the people involved with discharging the vessel, the crew and the security staff. These would need to be present anyway and are considered essential to the task. Fatalities and serious injuries to members of the general public not involved with this task are expected to be in single figures, probably less than 5, although this is dependant on the use of the café/shop.

38. A number of other operating conditions have been put in place; these include restrictions on berthing or disembarking explosives if cruise liners are present, discharging HD1.1 cargo first so as to reduce the overall HD1.1 quantity, requesting that a tug with fire fighting capability is on standby, and restricting activities if other vessels with dangerous goods, particularly LPG, LNG or Petroleum Spirit are in the vicinity.

39. The two areas that are outside of our control and still pose the potential for a high consequence are the café/shop and the marina. It is anticipated that activity in these after 22:30 will be low, but cannot be guaranteed.

40. If it is required that a vessel must berth and discharge explosives during normal working hours, then, depending on HD and NEQ, it may require referring up through our chain of command for the potential residual risks and consequences to be accepted by the Secretary of State for Defence.

41. However, by complying with the conditions of the instruction issued by the UK Chief Inspector of Explosives, it is believed that we can demonstrate that we have reduced the risks to Salalah Port and the local population to ALARP, and that the residual risks and potential consequences are tolerable. The FN curve would indicate that principally the risk is to the workers disembarking the explosives; this is as would be expected.

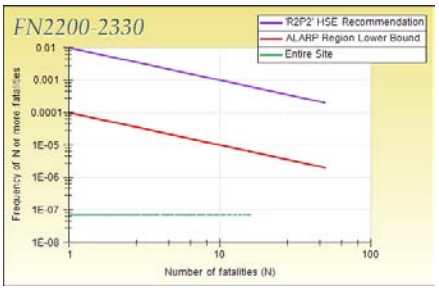


Fig.15 FN Curve 22:00 – 23:30

XRA Considerations

42. In reviewing the arrangements at Salalah Port we used Explosion Risk Assessment (XRA) Version 1.0 to assess the risks and identify the potential consequences. XRA version 1.0 has been replaced by Version 1.1.

43. There are a number of limitations with XRA that undermine the output.

a. XRA does not account for topography; in this case the exposed sites external to the port were out of line of sight and protected by rising ground. This resulted in the model assuming line of sight and therefore a greater hazard from the primary fragmentation. We attempted to mitigate this by declaring the PES as traversed. High

velocity low angle fragmentation is then removed. What is left is the blast and lobbed fragmentation effects.

b. The programme cannot take account of multiple ammunition natures. We either had to declare the total NEQ as 1000 lb Aircraft Bombs or as 155mm artillery Shell. Both are not representative of the actual hazard. The 155mm Artillery Shell model was used because there is no model for the 105mm HE Shell in the XRA programme. Whatever the model used currently, the results will not be accurate due to the multiple ammunition types. Work is ongoing to allow XRA to manage multiple ammunition types.

Conclusion

44. Under UK rules the Salalah Port would not be issued an explosives licence where the current operating conditions apply. Based on one movement annually the risk is within the Broadly Acceptable region, but should that risk be realised the consequences would be intolerable if we were to be using the port whilst it was operating normally. Under UK rules we do not licence to risk alone, but to consequence. Therefore we should not use the port during normal operating hours.

45. The mitigation measures put in place reduce the time that the explosives are in the port and the numbers of non involved people potentially at risk. The measures are reasonable and practicable; therefore we have a duty to comply with them. There is the added benefit that a shorter time at the berth will incur less charges!

Stuart Hooper
Jun 2010

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MINISTRY OF DEFENCE

INTRODUCTION

- **Background**
- **Salalah Port**
- **UK OME Hazards**
- **Exposed Sites**
- **Mitigation**

BACKGROUND

- UK RAF Has a requirement for hot weather flying training
- SF Training
- Long history of support to the Oman
- Sealift vs Airlift

SULTANATE OF OMAN

MINISTRY OF DEFENCE

de&s

SALALAH PORT

CONTAINER TERMINAL

GENERAL CARGO TERMINAL

EXPOSED SITES SOUTH OF GCT

EXPOSED SITES

EXPOSED SITES

EXPOSED SITES

UK EXPLOSIVES HAZARDS

- Exercise Magic Carpet = 8500 Kg HD1.1
  - 6000 Kg Mk 20 Aircraft Bombs 1000lb
  - 2500 Kg Demolition explosives and other HD explosives.

- Other cargo = 22500 Kg HD1.1
  - Shell 105mm HE = 19000Kg
  - Demolition explosives = 2000 Kg
  - Other HD's = 1500 Kg

POTENTIAL EXPLOSIVE LIMITS

- HD1.1
  - Nil due to warehouses and café/shop
  - 4400 Kg if Marina becomes the limiting factor or 14800 Kg if everyone on a vessel in the marina is below decks
  - 30700 Kg if the GCT and Marina can be evacuated and the limiting factor becomes the GCT Operations Building

NORMAL OPERATIONS

- Lack of control for Inhabited Building Distance (30,000 Kg HD1.1 = 520m @16.7$Q^{1/3}$)
- Warehouses @ 35m & 85m
- DynCorps Warehouse @ 146m
- Café/shop @ 254m
- Workshops @ 230m
- Marina @ 273m
- GCT Ops @ 570m
- Port Control @ 570m
- Accommodation @ 730-830m
- Potential for c55+ fatalities (Higher if a cruise ship is present)

CONDITIONAL PROBABILITY OF FATALITY

30,000 Kg HD1.1

Persons in Open

Persons in Buildings

Probability = 1e-006
Probability = 0.0001
Probability = 0.01
Probability = 0.1
Probability = 0.5
Probability = 1

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EXPOSED SITES

CPOF WEAPON FRAGMENTATION

WF Persons in Buildings 30K Traversed, applies to ES protected by Bluff only

WF Persons in Open 30K Traversed, applies to ES protected by Bluff only.

Probability = 1e-006
Probability = 0.0001
Probability = 0.01
Probability = 0.1
Probability = 0.5
Probability = 1

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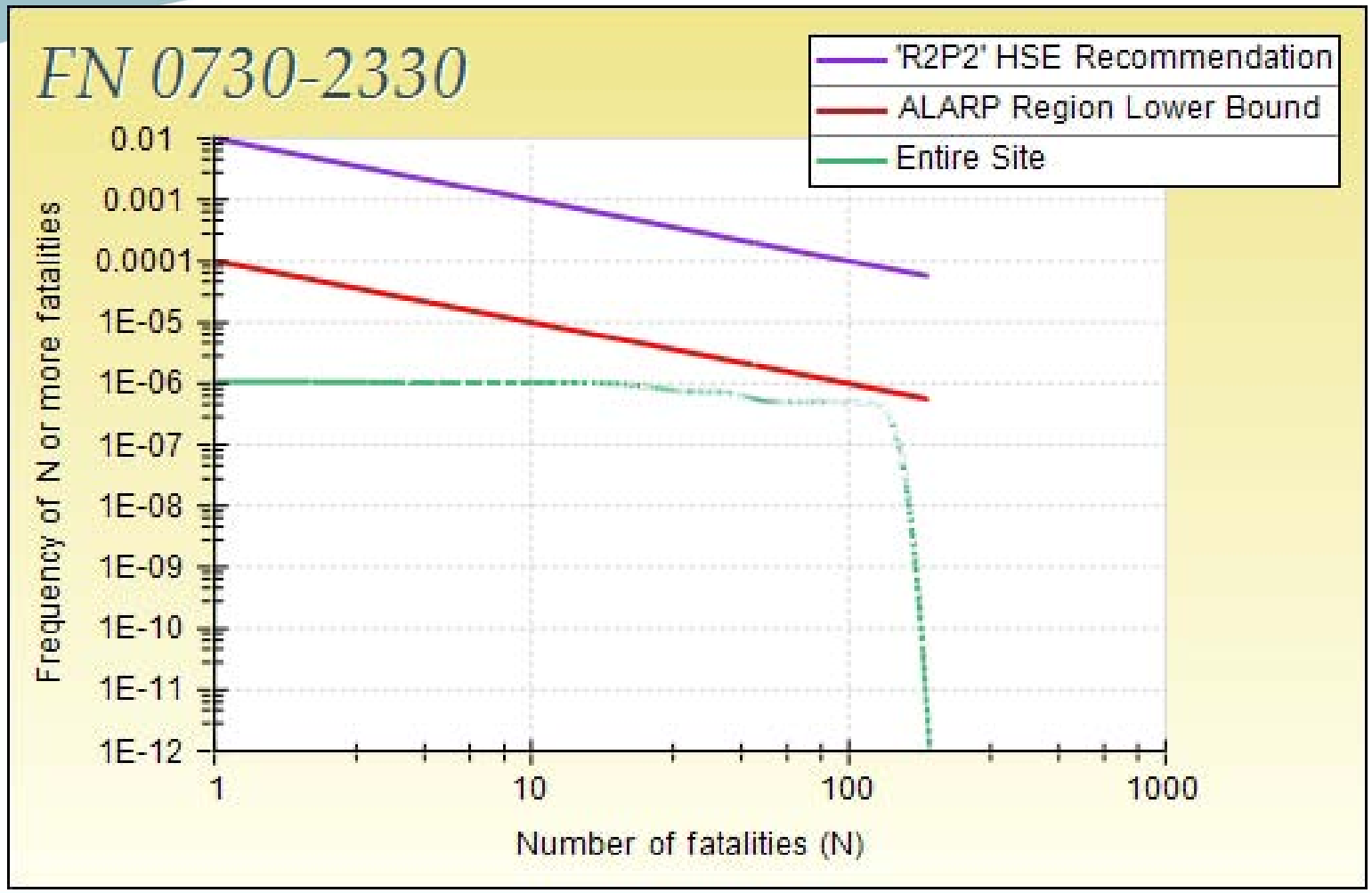
FN CURVE

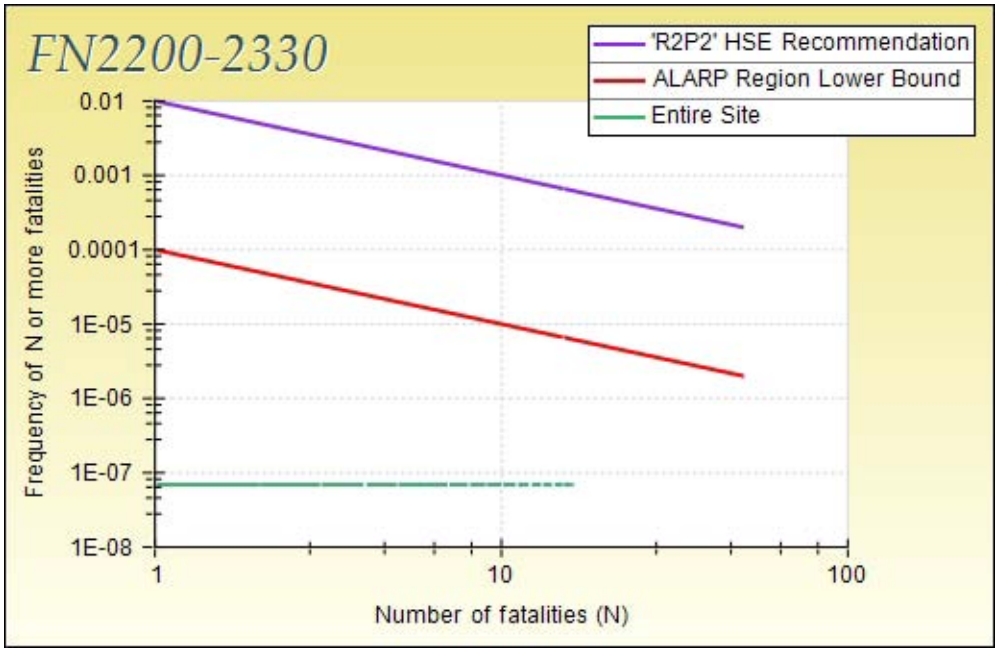

FN 0730-2330
'R2P2' HSE Recommendation
ALARP Region Lower Bound
Entire Site
Frequency of N or more fatalities
0.01
0.001
0.0001
1E-05
1E-06
1E-07
1E-08
1E-09
1E-10
1E-11
1E-12
1
10
100
1000
Number of fatalities (N)

CONCLUSIONS

- Occupied facilities do not met required separation distances.
- No licence could be issued under UK rules.
- Risk is Broadly Acceptable based on small frequency of operation.
- Potential worst case consequences would not be tolerable.
- Duty of care to reduce risks to ALARP

MITIGATION MEASURES

- Berthing times restricted.
- No handling if cruise ship present.
- No berthing if cruise ship is within $11.1Q^{1/3}$.
- Limitations if other DG present.
- HD1.1 discharged first.
- Fatalities generally limited.
- Risk are lower and measures are reasonable and practicable.
- Demonstrated risks are ALARP



UK USE OF SALALAH PORT

- ANY QUESTIONS?