Workplace Assesment 2005-1 - Shell Ondina® Oil 15 RAN School of Ship Safety and Survivability – West (SSSS-W) HMAS Stirling

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INTRODUCTION

The School of Ship Safety and Survivability – West (SSSS-W) at HMAS STIRLING is one of three Royal Australian Navy facilities responsible for shipboard damage control training. For many years these facilities used diesel fuel for realistic firefighting training, however concerns regarding environmental issues, and trainee and instructor exposure to diesel smoke, resulted a change to LPG fire sources and separate smoke generators from 1995, the latter using Ondina® Oil 15 from Shell Australia.

This workplace assessment (WPA) results from concerns expressed vide Reference A after a SSSS-W occupational health and safety audit in July 2004, regarding the use of Ondina® for this purpose, given the proximity between the smoke outlets in the Gas-Fired Firefighting Unit (GFFFU) to naked flames, in temperatures of up to 300ºC. Although both trainees and instructors use Open Circuit Compressed Air Breathing Apparatus (OCCABA), the latter were also interested in perhaps using full-face respirators as an alternative to OCCABA, to facilitate better communication within the GFFFU.

AIM

The aim of this WPA was to assess the hazards to instructors associated with Ondina® smoke, using full-face respirators as an alternative to OCCABA.

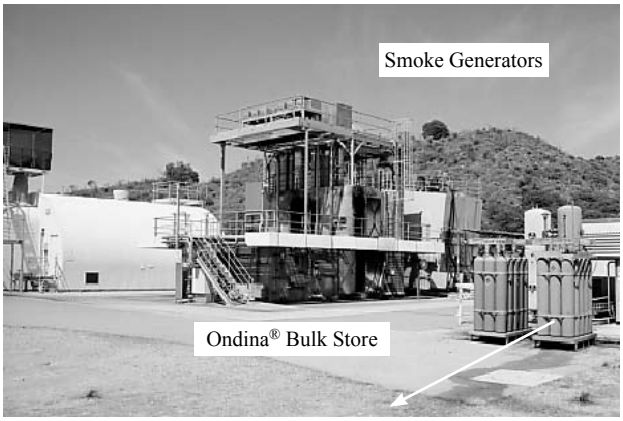
SCOPE

The scope of this WPA does not include Ondina® handling or storage, or the use of respirators with other chemicals at SSSS-W, such as triethylene glycol in the submarine damage control trainer, or O-Chlorobenzylidene Malonitrile (CS gas) for nuclear, biological and chemical training.

Description of SSSS-W Firefighting Processes

Physical Description. SSSS-W is 1.4 km north of Fleet Base West. The GFFFU is approximately 200m southwest of the SSSS-W office/ classroom building. Ondina® is piped from a bulk stowage to six smoke generators atop the GFFFU (one per GFFFU compartment). Each generator heats the oil to produce smoke without combustion, which is blown a fan via ducting to the compartment. SSSS-W staff advised that 4.5 litres of Ondina® is consumed for every hour of constant running of all generators. GFFFU training entails one instructor monitoring all compartments from a central passageway, the door to which is used by trainees to enter to GFFFU to begin firefighting.

Exposure Rates. SSSS-W has eight staff, all of whom work in the GFFFU. There are up to 24 trainees per course, which include:



The SSSS-W GFFFU, showing the smoke generators and Ondina® bulk store

1. Advanced Course. Advanced courses are provided approximately eight times per year (ie 192 personnel per year).

Damage Control Instructor's (DCI) Course. DCI courses are provided approximately five times per year (ie 120 people per year).

Pre-Workup Training (PWT). PWT is used to work up entire ship's companies (up to 220 people) prior to deployment. As each ship undergoes PWT at least annually, about 1660 personnel are exposed.

Instructors are therefore exposed at a rate of approximately 80 to 85 courses per year. Notwithstanding the use of OCCABA some smoke exposure is inevitable, not only in the GFFFU but also the immediate area outside. Most trainees are exposed

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for up to 20 minutes (once only each), while instructors may be exposed for up to four hours at a time, in three or four 20 minute blocks.

SSSS-W SAFETY RECORD

Review of SSSS-W's incident log from February 2003 to September 2004 showed a total of 19 incidents, all of whom only involved trainees. Most injuries consisted of minor burns and soft tissue injuries; none involved Ondina® smoke.

ONDINA® DESCRIPTION

The Shell Australia Technical Data Sheet (TDS) describes Ondina® as a white mineral oil that has been refined to virtually eliminate Polycyclic Aromatic Hydrocarbons (PAH). It complies with US and UK pharmacopoeia regulations, and US Food and Drug Administration food additive regulations. It is not classified as dangerous per the Australian Code for the Transport of Dangerous Goods.

The only relevant section of the Shell Australia Materiel Safety Data Sheet (MSDS) for Ondina®, is that with a flash point of approximately 170ºC, it is combustible only if preheated. The upper and lower explosive limits are the same (0.45 % v/v). The only reference with respect to hazardous combustion products is that they contain carbon oxides.

LITERATURE SEARCH

The Shell Technical data Sheet (TDS) states that the use of Ondina® for smoke generation is not recommended, although the reason was not specified.

References B-D are occupational health assessments of Australian and UK naval firefighting training facilities during the 1980's. As Ondina® was not used at the time their relevance in the current context is marginal. As these assessments are 20 years old, an update may be useful.

The US Army document vide Reference E describes 'fog oil' as an oil smoke produced by injecting mineral oil into a heated manifold. The oil is vaporized on heating and condenses when exposed to the atmosphere, producing respirable particles. The specifications for fog oil were changed in 1986 to require the removal of all carcinogenic components or additives. The US Army Centre for Health Promotion and Preventive Medicine estimates that the maximum permissible TWA for fog oil is 5 mg/m^3, 15 minutes is 360 mg/m^3, one hour 90 mg/m^3, and six hours is15 mg/m^3.

Reference F studied the use of mineral oil and other chemicals for theatrical smoke, with 439 adult actors in 16 musicals in 1997-99. It concluded:

a. No evidence of serious health effects was found to be associated with exposure to mineral oil smoke.
b. Elevated exposures to mineral oil smoke are associated with increased reporting of throat symptoms.
c. There was no evidence of an additive or multiplicative increase in effect from exposure to more than one of the types of theatrical effects evaluated in this study.
d. Other factors besides theatrical effects associated with increased symptom reporting included perceived levels of stress, performance schedule, and level of physical effort.
e. Based on the observed association between increased signs and symptoms of respiratory irritant effects and exposure to elevated levels of mineral oil, it was recommended that exposures not exceed peak concentrations of 25 mg/m^3, and TWA exposures should be kept below 5 mg/m^3.

However, a major limitation of References E and F is their lack of relevance in the SSSS-W context, where Ondina® smoke coexists with high temperatures and naked flame.

HAZARD IDENTIFICATION

Hazard 1: Particulate Inhalation. The means by which Ondina® is used to make smoke suggests that the particulates mostly consist of amorphic carbon (carbon soot, or carbon black). The International Agency for Research on Cancer (IARC) noted that, although there is *sufficient evidence* of carcinogenicity in experimental animals for carbon black and its extracts, there is *inadequate evidence* in humans. IARC therefore classifies carbon black as a respiratory irritant and a Group 2B (*possible*) human carcinogen.

Besides its own properties, carbon soot usually contains complex organic molecules, including PAHs and other carcinogens. Although the dose of Ondina® smoke required to (possibly) cause cancer is far more than for diesel smoke because the former lack PAHs, the presence of LPG combustion byproducts at temperatures of up to 300ºC may result in the formation of PAHs and other carcinogens. However, Shell Australia has advised that this only occurs at temperatures exceeding 800 to 1000ºC.

f. The nature of the task means that the unmitigated probability of inhaling Ondina® smoke particulates at SSSS-W (within or without the GFFFU) is almost certain. With respect to unmitigated hazard severity:

g. Particulates Within GFFFU. As only enough smoke is produced within the GFFFU to limit visibility without total obscuration; it is likely that these probably do *not* exceed the NIOSH IDLH limit of 1570 mg/m^3. The unmitigated hazard severity is therefore at most major.

Particulates Outside GFFFU. NIOSH has a Recommended Exposure Level (REL) for mineral oil smoke of **3.5** mg/m^3 Time Weighted Average (TWA), compared to Reference F, which recommended that TWA exposure should be less than 5 mg/m^3. SSSS-W's incident reporting suggests that the unmitigated hazard severity outside the GFFFU is at most minor.

Hazard 2: Toxic Gases. The Ondina® MSDS states that the main combustion products are carbon oxides (ie CO and CO_2). CO can cause harm via its greater affinity for the haemoglobin molecule compared to O_2, while the latter is only toxic because it can displace O_2 from the air.

a. CO Within the GFFFU. The NOHSC exposure standard for CO is 30 ppm TWA, with no STEL. The unmitigated hazard severity for CO is considered critical, while exposure to CO within the GFFFU is almost certain.

b. CO Outside the GFFFU. As it can still cause harm outside the GFFFU, the unmitigated hazard severity for CO is still considered at least minor. Exposure to CO outside the GFFFU remains possible.

c. O_2 Depletion Within the GFFFU. NOHSC has no exposure standard for CO_2, stating only that the only requirement is that a sufficient O_2 concentration be maintained. If this is not achieved within the GFFFU, the unmitigated hazard severity is considered major.

d. O_2 Depletion Outside the GFFFU. As CO_2 is highly unlikely to displace enough O_2 to cause health problems outside the GFFFU, the unmitigated hazard severity is considered insignificant.

2. Hazard Quantification. With respect to the use of respirators by instructors as an alternative to OCCABA, the most important hazards were considered to be CO and O_2 depletion within the GFFFU. It was considered that quantifying smoke particulates was required only if the CO and O_2 results did not preclude the use of respirators.

3. These were quantitatively assessed using a calibrated Sensortec Impact Pro gas analyser from Zelweger Analytics, which measures O_2 flammables, O_2 and H_2S. Measurements were taken at either end of the instructor's passageway with the entry door shut or open (but covered by a fire hose on the 'waterwall' setting, and with the GFFFU shut down, with smoke only, and with smoke and flames. The results are as follows.

GFFFU Status	Passage End	Entry Door	O_2 (%air)	Flam	CO (ppm)	H_2S (ppm)
Shut Down	Door	Shut	21.9	0	0	0
	Non-door	Shut	21.9	0	0	0
	Door	Open (waterwall)	21.9	0	0	0
	Non-door	Open (waterwall)	21.9	0	0	0
Smoke only	Door	Shut	21.9	0	0	0
	Non-door	Shut	21.9	0	0	0
	Door	Open (waterwall)	21.9	0	0	0
	Non-door	Open (waterwall)	21.9	0	0	0
Smoke & Flame	Door	Shut	**18.0**	0	**36**	0
	Non-door	Shut	**20.3**	0	**12**	0
	Door	Open (waterwall)	**19.6**	**1**	**25**	0
	Non-door	Open (waterwall)	**19.5**	**1**	**12**	0

2. These results suggest that both O_2 depletion and CO are a *not* a concern in the instructor's passageway unless the GFFFU is fully functional. The reason for this relates not to the intrinsic properties of the Ondina® smoke, but from O_2 consumption and CO production from the LPG burners. For this reason, **respirators are not considered suitable for instructor use when the GFFFU is fully operational**.

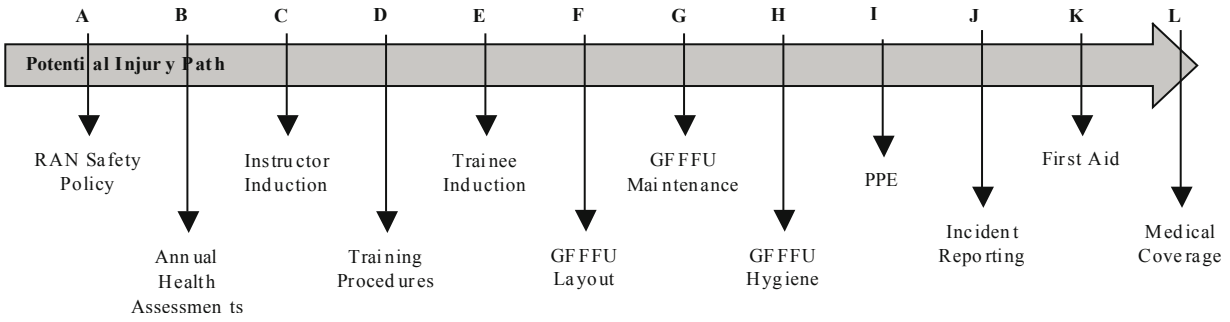
UNMITIGATED HAZARD RISK ASSESSMENT

The *unmitigated* hazards per the hazard assessment tables at Appendix E to Reference G (repeated vide Annex A) are assessed per the following table:

Hazard	Unmitigated Hazard Probability	Unmitigated Hazard Consequences	Unmitigated HRI
1a Particulate inhalation within GFFFU	Almost Certain	Major	EXTREME
1b. Particulate inhalation outside GFFFU	Almost Certain	Minor	HIGH
2a. CO within GFFFU	Almost Certain	Critical	EXTREME
2b. CO outside GFFFU	Possible	Minor	MODERATE
2c. O_2 depletion within GFFFU (CO_2)	Likely	Major	HIGH
2d. O_2 depletion outside GFFFU (CO_2)	Rare	Insignificant	LOW

HAZARD CONTROLS

SSSS-W's hazard controls identified in this WPA are summarised per the following diagram. There may be other controls that have *not* been identified in this WPA.



a. Control A: Safety Policy. RAN safety management policy is at Reference G. SSSS-W safety management is part of the RAN SHORESAFE program.

b. Control B: Annual Health Assessments. All RAN personnel undergo an Annual Health Assessment. However, as at present this is limited to identifying lifestyle rather than occupational health issues, its effectiveness (particularly for instructors) is limited. Other workplaces besides SSSS-W have similar concerns.

c. Control C: Instructor Induction. All instructors have completed damage control training and undertake a further one week instructor's course. Other induction processes includes SSSS-W standing orders and workplace instructions, knowledge of emergency shutdown procedures, and location of materiel safety data sheets.

d. Control D: Training Procedures. SSSS-W training procedures are comprehensively documented and under continual review. The training entails safety briefs and observation of practical demonstrations.

e. Control E: Trainee Induction and Supervision. The course is designed such that trainees are required to demonstrate satisfactory performance prior to progressing to the next stage of their training. They are therefore closely monitored by instructors throughout their training.

f. Control F: GFFFU Layout. The GFFFU is laid out to facilitate rapid casualty evacuation. Casualty exercises are performed quarterly.

g. Control G: GFFFU Maintenance. SSSS-W maintenance is performed by a contractor on behalf of Defence Corporate Services and Infrastructure Group (CSIG), as for all other facilities at HMAS STIRLING. Staff have expressed concern that they lack visibility on CSIG management processes for the GFFFU. The GFFFU is also cleaned of soot accumulation

quarterly by the instructors, who wear respirators and disposable impermeable overalls whilst doing so.

h. Control H: Hygiene Facilities. SSSS-W has emergency showers and eyewash stations in addition to the normal ablution facilities.

i. Control I: PPE. PPE during the training include overalls, gloves, hoods boots and OCCABA. The training includes instruction on proper fit and use. As previously indicated, respirators are not suitable in the GFFFU.

j. Control J: Incident Reporting. The RAN has a comprehensive process for OHS incident and accident reporting.

k. Control K: First Aid. All RAN personnel undergo first aid training.

l. Control L: Medical Coverage. Medical coverage is provided by Fleet Base West Health Centre, which has an ambulance and medical response covering all of HMAS STIRLING

POST-MITIGATED HAZARD RISK ASSESSMENT

The *post-mitigated* hazards per the hazard assessment tables at Annex A, using SSSS-W's *current* controls identified previously, are assessed as follows:

Hazard	Pre-Mitigated HRI	Hazard Controls and Mitigation	Post-Mitigated Hazard Probability	Post-Mitigated Hazard Consequences	Post-Mitigated HRI
1a Particulate inhalation within GFFFU	EXTREME	A, C, D, E, F, G, H, I, J, K, L	Possible	Minor	MODERATE
1b. Particulate inhalation outside GFFFU	HIGH	A, D, H, I, J, K, L	Possible	Insignificant	LOW
2a. CO within GFFFU	EXTREME	A, C, D, E, F, G, H, J, K, L	Possible	Minor	MODERATE
2b. CO outside GFFFU	MODERATE	A, C, D, E, F, G, H, J,K, L	Possible	Insignificant	LOW
2c. O_2 depletion within GFFFU (CO_2)	HIGH	A, H, I, J, K, L	Possible	Minor	MODERATE
2d. O_2 depletion outside GFFFU (CO_2)	LOW	A, H, I, J, K, L	Rare	Insignificant	LOW

REVIEW OF HAZARD RISK ASSESSMENT

Hazard Risk Assessment Limitations. It should be noted that the pre- and post-mitigated HRI's are based on Annex A, which is taken directly from Reference G. Noting that Reference G states that the measures used should reflect the nature of the organisation and the activity being assessed, it is possible that this may *not* be the case with respect to the measures used in this WPA. SSSS-W may therefore prefer to apply the process used in this WPA using its *own* hazard risk measures.

Effectiveness of Controls. Comparison of the pre- and post-mitigated HRIs for suggest that SSSS-W's current controls for Ondina® smoke are generally adequate with two significant deficiencies, neither of which are within its ability to control.

Firstly, it is noted that the current health surveillance process for RAN personnel is not suitable for SSSS-W instructors. Noting the lack of efficient biological surveillance for CO_2 and CO, it is suggested that any process for SSSS-W instructors should focus on particulate exposure.

A literature search has so far been unable to *confirm* whether in fact the low hazard associated with Ondina® smoke *is* in fact altered by the presence of high temperature and naked flame.

Other Hazard Mitigation Measures for Consideration. Options for further mitigation using the following hierarchy of controls include:

a. Elimination. The safest option is not to use 'real' smoke and flame for firefighting training at all: no hazard means nothing to mitigate.

However, SSSS-W's role is considered to have been validated in real incidents, in particular the fire aboard HMAS WESTRALIA in 1998.

b. Design or Substitution. This refers to the use of less hazardous materials or processes. This has already occurred with respect to ceasing the use of diesel fuel for this purpose in the mid 1990's.

c. Engineering Controls. Examples include isolating hazardous equipment or other hazards, the use of mechanical aids as an alternative to manual handling, and machine guards. The GFFFU engineering controls appear to be of a high standard; what is less clear is SSSS-W visibility on CSIG's GFFFU management processes.

d. Administration. This refers to how SSSS-W organises its work, via documented work procedures and instructions. Present arrangements appear to have been validated (particularly with respect to the use of OCCABA instead of respirators), however they require ongoing monitoring.

e. Training. This refers to ensuring that SSSS-W staff have the appropriate skills to perform their work efficiently and safely, and awareness of the associated hazards. Present standards appear adequate for the task but require ongoing monitoring.

f. Personal Protective Equipment. Although the cheapest option, PPE is the least effective solution, as it entails employee compliance with equipment that may be difficult to use, uncomfortable to wear, and impede job performance. However, as one of the main reasons for SSSS-W's existence is to train RAN personnel in PPE use (not just for firefighting but also NBC incidents), not using PPE would defeat SSSS-W's purpose.

Finally, the hazards associated with Ondina® smoke should be set in two wider contexts:

a. Firstly, although they have not been eliminated, the hazards are significantly reduced when compared to the use of diesel fuel ten years ago, and
b. Secondly, SSSS-W hazards should be balanced against the preventable morbidity and mortality associated with actual fires aboard RAN ships.

CONCLUSION AND RECOMMENDATIONS

The hazards associated from Ondina® smoke at SSSS-W are most likely limited to carbon soot and CO. Both pose significant threats within the GFFFU, however the mitigating controls appear acceptable. The risk outside the GFFFU also appears acceptable. It is recommended that:

a. Current health surveillance processes for SSSS-W instructors require review, with a focus on monitoring particulate exposure.
b. Until it can be confirmed whether the low hazard associated with Ondina® smoke is in fact altered by the presence of high temperature and naked flame, measures to reduce instructor exposure to as low as is reasonably achievable should be maintained. An assessment of particulate exposure in and around the GFFFU may be part of this process.
c. The risks associated with Ondina® smoke appear to be less than that from the LPG burners with respect to CO production and O_2 depletion. This means that instructors should continue to use OCCABA in the GFFFU.

ACKNOWLEDGEMENT

I would like to express my sincere thanks to SSSS-W staff for their time and assistance with this WPA.

ANNEX:

Hazard Assessment Tables
2.

REFERENCES:

A. SSSS-W Minute 96/07/102 26/04 dated 10 Sep 04
B. Commonwealth Institute of Health Minute 81/398 dated 22 Mar 82
C. Flag Officer Naval Support Command Minute RANH(P) C23(b) N86-3-113 dated 03 Mar 87
D. Searing, C.S.M., Smith, R.J., Pethybridge, R.J., Goad, R.F., Legg, S.J. Lung Function in Royal Naval Firefighting Instructors. *Journal of the Royal Naval Medical Service* 1986; Vol 72 pp 94-103.
E. US Army Center for Health Promotion and Preventive Medicine (USAHPPM) fact sheet 65-021-0503 *Fog Oil – Medical* (17 Feb 05)
F. Moline, J.M., Golden, A.L., Highland, J.H., Wilmarth, K.R., Kao, A.S. *Health Effects Evaluation Of Theatrical Smoke, Haze, And Pyrotechnics*, prepared for Equity-League Pension and Health Trust Funds dated 06 Jun 00
G. ABR 6303 *NAVSAFE Manual: Navy Safety Management* dated 29 Jan 02

HAZARD ASSESSMENT TABLES

Reference:

A. Standards Australia AS/NZS 4360:1999 Risk Management dated 12 Apr 99

Note: Reference A states that the measures used should reflect the nature of the organisation and the activity being assessed. As the information in this Annex is taken directly from Reference A, this may not reflect SSSS-W's own hazard assessment.

Qualitative measures of consequence or impact

LEVEL	DESCRIPTOR	DETAIL DESCRIPTION
1	INSIGNIFICANT	No injuries, no loss of production capability, low financial loss
2	MINOR	First aid treatment, short-term partial loss of production capability, medium financial loss
3	MAJOR	Medical treatment, long-term partial loss of production capability, high financial loss
4	CRITICAL	Extensive injuries, short-term total loss of production capability, major financial loss
5	CATASTROPHIC	Death, long-term total loss of production capability, huge financial loss

Qualitative measures of likelihood

LEVEL	DESCRIPTOR	DETAIL DESCRIPTION
A	ALMOST CERTAIN	Is expected to occur in most circumstances
B	LIKELY	Will probably occur in most circumstances
C	POSSIBLE	Might occur at some time
D	UNLIKELY	Could occur at some time
E	RARE	May occur only in exceptional circumstances

Qualitative Risk Analysis Matrix

	Hazard Severity				
Hazard Probability	INSIGNIF-ICANT	MINOR	MAJOR	CRITICAL	CATASTRO-PHIC
ALMOST CERTAIN	HIGH	HIGH	EXTREME	EXTREME	EXTREME
LIKELY	MODERATE	HIGH	HIGH	EXTREME	EXTREME
POSSIBLE	LOW	MODERATE	HIGH	EXTREME	EXTREME
UNLIKELY	LOW	LOW	MODERATE	HIGH	EXTREME
RARE	LOW	LOW	MODERATE	HIGH	HIGH