



Control Framework – Mobile Equipment Fire Management

Control Framework Mapping Examples only

EMESRT CFw Equipment Fires Examples

VERSION SOURCE - MAY 2019

Series 1 - Table of Required Operating States (ROS) mapped to Relevant Credible Failure Modes

Required Operating State (ROS)	Relevant Credible Failure Modes
<p>ROS-EF-01 Mobile plant design prevents interactions between flammable materials, fuel and ignition sources.</p> <p><i>This required operating state applies for all mobile equipment. As required, additional design elements are included for approved for use underground applications This includes fuel, flammable materials and any other items which could combust</i></p>	<ul style="list-style-type: none"> ▲ CFM-DE-01 Liquid fuel loss of containment - design weakness ▲ CFM-DE-02 Solid fuel present on mobile equipment - specification weakness ▲ CFM-DE-03 Fuel is introduced to mobile equipment - design weakness ▲ CFM-DE-04 Excessive heat is produced and not effectively contained/shielded from fuel sources during mobile equipment operation - design weakness ▲ CFM-DE-10 OEM does not provide an appropriate maintenance strategy for the supplied plant ▲ CFM-DE-31 New generation of mobile equipment - fire potential and pathways not recognized ▲ CFM-MN-30 Recommendations from OEM or Third Party Supplier not implemented ▲ CFM-DT-01 Liquid fuel loss of containment - not detected ▲ CFM-DT-10 Detection and/or suppression system compromised - no signal on fire or potential fire situation ▲ CFM-LR-12 Fire suppression activated but does not extinguish or prevent a mobile equipment fire
<p>ROS-EF-02 Mobile plant is maintained to a schedule and to OEM standards. Specific fire prevention and mitigation checks are part of the maintenance process. There are no early operational failures.</p> <p><i>Mobile equipment is maintained to OEM standards taking into account the operating environment e.g. more frequent maintenance and servicing if required. Maintenance standards extend to third party modifications. Maintenance tasks are well planned and executed e.g. hot work is well managed. Maintenance processes include quality checks before equipment is returned to service</i></p>	<ul style="list-style-type: none"> ▲ CFM-MN-11 Equipment returned to service without required checks and sign off ▲ CFM-MN-01 Liquid Fuel loss of containment - substandard maintenance ▲ CFM-MN-02 Solid fuel, components present on mobile equipment become fuel - inadequate maintenance standards ▲ CFM-MN-03 Fuel is introduced to mobile equipment - inadequate maintenance standards ▲ CFM-MN-04 Inadequate Maintenance results in excessive heat during subsequent mobile equipment operations ▲ CFM-MN-05 External heat source is introduced to mobile equipment during maintenance ▲ CFM-MN-06 Fire suppression systems do not function or are inadequate - inadequate maintenance ▲ CFM-DE-10 OEM does not provide an appropriate maintenance strategy for the supplied plant ▲ CFM-DE-32 Fire suppression system fails because of interface logic issues ▲ CFM-DE-33 Fire suppression systems design, configuration and installation outsourced to third party - provided to operator without specification or OEM oversight. ▲ CFM-DE-31 New generation of mobile equipment - fire potential and pathways not recognized

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Required Operating State (ROS)	Relevant Credible Failure Modes
<p>ROS-EF-03 Mobile plant is operated productively and safely within operating design limits, avoiding fire or potential fire incidents.</p> <p><i>Mobile equipment is operated within equipment design limits to avoid generating excessive heat or fuel loads.</i></p>	<ul style="list-style-type: none"> ⚠ CFM-OP-11 Pre-start checks do not identify damaged or missing insulation, fuel build-up or compromised fire prevention/response component faults ⚠ CFM-OP-13 Workers operate mobile plant in a way which increases fuel loads, compromises protection systems or generates ignition sources ⚠ CFM-OP-40 Unapproved mobile equipment put into service ⚠ CFM-OP-01 Liquid fuel loss of containment - operating beyond equipment design capabilities ⚠ CFM-OP-02 Solid fuel - components present on mobile equipment become fuel ⚠ CFM-OP-03 Fuel is introduced to mobile equipment - during operations ⚠ CFM-OP-04 Excessive heat is produced during mobile equipment operation - operating outside design parameters ⚠ CFM-OP-05 External heat or other high energy source is introduced to mobile equipment during operations ⚠ CFM-OP-06 Fire suppression systems does not function or is inadequate - during operations ⚠ CFM-DE-31 New generation of mobile equipment - fire potential and pathways not recognized

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Required Operating State (ROS)	Relevant Credible Failure Modes
<p>ROS-EF-04 Local Response to fires or potential fires on mobile equipment - early detection with effective local response.</p> <p><i>Mobile equipment operators and other workers are trained and capable to respond to mobile equipment fires. This includes following site emergency protocols if the fire cannot be extinguished.</i></p>	<ul style="list-style-type: none"> ▲ CFM-DE-06 Fire suppression systems do not function or are inadequate - design fault ▲ CFM-DE-10 OEM does not provide an appropriate maintenance strategy for the supplied plant ▲ CFM-DE-31 New generation of mobile equipment - fire potential and pathways not recognized ▲ CFM-DE-32 Fire suppression system fails because of interface logic issues ▲ CFM-DE-33 Fire suppression systems design, configuration and installation outsourced to third party - provided to operator without specification or OEM oversight. ▲ CFM-OP-06 Fire suppression systems does not function or is inadequate - during operations ▲ CFM-DT-01 Liquid fuel loss of containment - not detected ▲ CFM-DT-04 Excessive heat is produced during mobile equipment operation - not detected ▲ CFM-DT-05 External heat or other high energy contact with mobile equipment not detected ▲ CFM-DT-10 Detection and/or suppression system compromised - no signal on fire or potential fire situation ▲ CFM-LR-01 Liquid fuel loss of containment - not able to shut down or actuate fire suppression ▲ CFM-LR-02 Solid fuel, components present on mobile equipment smoulder or burn - not able to extinguish ▲ CFM-LR-03 External fuel introduced to mobile equipment begins to smoulder or burn - not able to extinguish ▲ CFM-LR-04 Excessive heat is produced during mobile equipment operation leads to smoulder or burn - not able to extinguish ▲ CFM-LR-05 External fire or other high energy contact leads to smoulder or burn - not able to locally extinguish ▲ CFM-LR-10 Operator does not activate suppression systems or use fire extinguisher in a fire or potential fire situation ▲ CFM-LR-11 Operator parks/abandons mobile equipment on fire or potentially on in a sub optimal location - unable to extinguish ▲ CFM-LR-12 Fire suppression activated but does not extinguish or prevent a mobile equipment fire ▲ CFM-LR-13 Mobile Equipment Operator or nearby workers unable to escape fire or its effects

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Required Operating State (ROS)	Relevant Credible Failure Modes
<p>ROS-EF-09 Effective Emergency Response beyond local response limits fire losses.</p> <p><i>If there is a fire of potential fire on or around mobile equipment, then there is an effective emergency response that protects lives and property.</i></p>	<ul style="list-style-type: none"> ⚠ CFM-ER-20 Emergency Responders not called or otherwise delayed ⚠ CFM-ER-21 Emergency Responders take actions which make the effects of the fire more significant ⚠ CFM-ER-01 Liquid fuel loss of containment - not considered during emergency response ⚠ CFM-LR-13 Mobile Equipment Operator or nearby workers unable to escape fire or its effects ⚠ CFM-DE-31 New generation of mobile equipment - fire potential and pathways not recognized
<p>ROS-EF-05 Maintenance activities on or around mobile equipment do not cause fires.</p> <p><i>Hot work on or around mobile equipment does not cause fires on mobile equipment, infrastructure, or work environment.</i></p>	<ul style="list-style-type: none"> ⚠ CFM-MN-05 External heat source is introduced to mobile equipment during maintenance ⚠ CFM-DE-31 New generation of mobile equipment - fire potential and pathways not recognized

SERIES 4 - Business Inputs that prevent or mitigate Equipment Fires mapped to Credible Failure modes

Table 4.2 Fit for Purpose Equipment Business Inputs mapped to Credible Failure Modes (part)

Business Inputs	Credible Failure Mode
<p>BI-02.01 Introduction of equipment to site process</p>	<ul style="list-style-type: none"> ⚠ CFM-DE-01 Liquid fuel loss of containment - design weakness ⚠ CFM-DE-02 Solid fuel present on mobile equipment - specification weakness ⚠ CFM-DE-03 Fuel is introduced to mobile equipment - design weakness ⚠ CFM-MN-30 Recommendations from OEM or Third Party Supplier not implemented ⚠ CFM-DE-10 OEM does not provide an appropriate maintenance strategy for the supplied plant ⚠ CFM-DE-30 Third party recommendations (alerts) not reacted to by OEM ⚠ CFM-OP-40 Unapproved mobile equipment put into service ⚠ CFM-DT-10 Detection and/or suppression system compromised - no signal on fire or potential fire situation ⚠ CFM-DE-33 Fire suppression systems design, configuration and installation outsourced to third party - provided to operator without specification or OEM oversight. ⚠ CFM-DE-31 New generation of mobile equipment - fire potential and pathways not recognized
<p>BI-02.02 Maintenance requirements cover all safety and operational systems on mobile plant</p>	<ul style="list-style-type: none"> ⚠ CFM-MN-01 Liquid Fuel loss of containment - substandard maintenance ⚠ CFM-MN-02 Solid fuel, components present on mobile equipment become fuel - inadequate maintenance standards ⚠ CFM-MN-03 Fuel is introduced to mobile equipment - inadequate maintenance standards ⚠ CFM-MN-04 Inadequate Maintenance results in excessive heat during subsequent mobile equipment operations ⚠ CFM-MN-05 External heat source is introduced to mobile equipment during maintenance ⚠ CFM-MN-06 Fire suppression systems do not function or are inadequate - inadequate maintenance ⚠ CFM-LR-01 Liquid fuel loss of containment - not able to shut down or actuate fire suppression ⚠ CFM-MN-11 Equipment returned to service without required checks and sign off ⚠ CFM-MN-30 Recommendations from OEM or Third Party Supplier not implemented

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Business Inputs	Credible Failure Mode
BI-02.07 Regular checking and maintenance of brakes, steering and tyres	<ul style="list-style-type: none"> ⚠ CFM-MN-04 Inadequate Maintenance results in excessive heat during subsequent mobile equipment operations ⚠ CFM-LR-02 Solid fuel, components present on mobile equipment smoulder or burn - not able to extinguish
BI-02.08 Fire suppression system is integrated into machine operation	<ul style="list-style-type: none"> ⚠ CFM-DT-10 Detection and/or suppression system compromised - no signal on fire or potential fire situation ⚠ CFM-DE-06 Fire suppression systems do not function or are inadequate - design fault ⚠ CFM-DE-10 OEM does not provide an appropriate maintenance strategy for the supplied plant ⚠ CFM-DE-32 Fire suppression system fails because of interface logic issues ⚠ CFM-DE-34 Fire suppression system specification, design, install, test and maintenance involves multiple organisations ⚠ CFM-DE-33 Fire suppression systems design, configuration and installation outsourced to third party - provided to operator without specification or OEM oversight. ⚠ CFM-MN-06 Fire suppression systems do not function or are inadequate - inadequate maintenance ⚠ CFM-OP-06 Fire suppression systems does not function or is inadequate - during operations
BI-02.09 Regular checking and maintenance of alarms and monitors	<ul style="list-style-type: none"> ⚠ CFM-MN-04 Inadequate Maintenance results in excessive heat during subsequent mobile equipment operations ⚠ CFM-DT-04 Excessive heat is produced during mobile equipment operation - not detected ⚠ CFM-LR-01 Liquid fuel loss of containment - not able to shut down or actuate fire suppression ⚠ CFM-LR-04 Excessive heat is produced during mobile equipment operation leads to smoulder or burn - not able to extinguish ⚠ CFM-DT-01 Liquid fuel loss of containment - not detected ⚠ CFM-DT-10 Detection and/or suppression system compromised - no signal on fire or potential fire situation
BI-02.11 An effective maintenance strategy for electrical components	<ul style="list-style-type: none"> ⚠ CFM-DE-02 Solid fuel present on mobile equipment - specification weakness
BI-02.13 Routine tyre inspection	<ul style="list-style-type: none"> ⚠ CFM-OP-04 Excessive heat is produced during mobile equipment operation - operating outside design parameters




















Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019









Business Inputs	Credible Failure Mode
BI-02.21 Design of components means they cannot be fitted wrongly e.g. turbo chargers on backwards	<ul style="list-style-type: none"> ⚠ CFM-MN-01 Liquid Fuel loss of containment - substandard maintenance ⚠ CFM-MN-11 Equipment returned to service without required checks and sign off
BI-02.22 Design of hydrocarbon and fuel tanks are maintainable and prevent leaking	<ul style="list-style-type: none"> ⚠ CFM-DE-01 Liquid fuel loss of containment - design weakness

SAMPLE










SERIES 6 - Credible Failure modes (with scenarios) mapped to Incidents and Business Inputs










Table 6.2 Maintenance Credible Failure Modes mapped to Incidents and Business Inputs

Maintenance Credible Failure Modes (with scenarios)	Incident Alerts and Analysis	Business Inputs that Prevent or Mitigate this CFM
<p>CFM-MN-01 Liquid Fuel loss of containment - substandard maintenance.</p> <p><i>During normal operations, there is a failure of reservoirs, hoses or lines containing fuel, hydraulics, lubrication, coolant etc. caused by:</i></p> <ul style="list-style-type: none"> <i>* leaks from over tightening or under tightening of hoses and lines or</i> <i>* rubbing or wear fail because maintenance and re installation of hoses, lines is outside of OEM or third party supplier recommendations</i> <i>* the released liquid is a fuel that can be ignited e.g. turbo charger, exhaust, electrical fault, etc.</i> <i>* the failure leading to the release of liquid is due to substandard maintenance of OEM or third party equipment components</i> 	<ul style="list-style-type: none">  D8 - Fire and explosion risks on hydraulic excavators - V1  D11 - Fire on diesel electric truck - V1  D12 - Fires on mine sites - V1  D13 - Rear hub failure and subsequent fire - V1  D14 - Fixed plant and mobile equipment fires on surface coal mines - V1  D17 - SA12-01-Inappropriate-maintenance-practices-and-fire-protection-lead-to-major-plant-fire  D6 - Diesel engine - turbocharger fires - V1  D7 - Equipment fires, investigation and response - V1  D21 - Safety-Alert-04-02-Fire-traps-truck-driver1 	<ul style="list-style-type: none">  BI-01.01 Trained personnel who are supported by an appropriate and up-to-date training management system  BI-01.13 Clear maintainer performance management expectations supported by an active and consistent performance management process  BI-02.02 Maintenance requirements cover all safety and operational systems on mobile plant  BI-01.51 Skilled and experienced personnel are accountable for maintaining mobile equipment  BI-01.50 Trained and competent personnel carry out error free hose assembly  BI-02.21 Design of components means they cannot be fitted wrongly e.g. turbo chargers on backwards  BI-02A.02 Fit for purpose equipment selection processes - fuel, lubrication and hydraulic lines  BI-03.06 Burst protection on hoses  BI-02A.50.1 Flammable Fluid Line Control Systems detect and react to loss of containment  BI-04.04 Site change management process apply to the introduction of new types and models of mobile equipment

Maintenance Credible Failure Modes (with scenarios)	Incident Alerts and Analysis	Business Inputs that Prevent or Mitigate this CFM
<p>CFM-MN-02 Solid fuel, components present on mobile equipment become fuel - inadequate maintenance standards.</p> <p><i>Solid components form a fuel source, caused by:</i></p> <ul style="list-style-type: none"> <i>* flammable components (e.g. covers) left in contact with hot components (e.g. turbo charger, exhaust etc.)</i> <i>* installation of component(s) that are flammable and/or outside OEM specifications</i> <i>* remove/fail to replace protective barriers between hot and flammable components</i> 	<p> D12 - Fires on mine sites - V1</p>	<ul style="list-style-type: none">  BI-01.01 Trained personnel who are supported by an appropriate and up-to-date training management system  BI-01.13 Clear maintainer performance management expectations supported by an active and consistent performance management process  BI-02.02 Maintenance requirements cover all safety and operational systems on mobile plant  BI-02.50 Plant Safety Files - Requirement to register and track plant components and certificates  BI-01.51 Skilled and experienced personnel are accountable for maintaining mobile equipment  BI-02A.58 Ceramic coatings for exhaust components  BI-04.04 Site change management process apply to the introduction of new types and models of mobile equipment

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Maintenance Credible Failure Modes (with scenarios)	Incident Alerts and Analysis	Business Inputs that Prevent or Mitigate this CFM
<p>CFM-MN-03 Fuel is introduced to mobile equipment - inadequate maintenance standards.</p> <p><i>During normal operations an external fuel source, introduced during maintenance ignites through contact with a hot surface such as a turbo charger, exhaust etc.</i></p> <p><i>Caused by:</i></p> <ul style="list-style-type: none"> <i>* rags</i> <i>* grease</i> <i>* solvents and degreaser</i> <i>* flammable containers or</i> <i>* other material left in engine bay</i> 	<ul style="list-style-type: none">  D12 - Fires on mine sites - V1  D23 - SB15-03-Fires-ignite-while-refuelling-mobile-plant  D61 - WA MSH_SB_100 Flammable Airconditioning Gas  D65 - WA MSH_SIR_181 Hydraulic Hose failure on Dump Truck 	<ul style="list-style-type: none">  BI-01.13 Clear maintainer performance management expectations supported by an active and consistent performance management process  BI-02.02 Maintenance requirements cover all safety and operational systems on mobile plant  BI-01.51 Skilled and experienced personnel are accountable for maintaining mobile equipment  BI-02.40 Introduction and Control of Materials on Site  BI-09.06 Site spill response

Maintenance Credible Failure Modes (with scenarios)	Incident Alerts and Analysis	Business Inputs that Prevent or Mitigate this CFM
<p>CFM-MN-04 Inadequate Maintenance results in excessive heat during subsequent mobile equipment operations.</p> <p><i>Fires following maintenance, caused by:</i></p> <ul style="list-style-type: none"> * During normal operations engine components rise above the ignition temperature of adjacent fuel sources caused by * Turbo failure e.g. heat shielding for turbocharger not replaced * Electrical fault (including cable runs or insulation being pinched/damaged, battery locations being compromised, etc.) * Friction between moving components e.g. collapsed wheel bearings * Operating without lubricants * Lagging on hot surfaces not repaired/replaced * Deflection barriers that separate oil hoses and fuel lines from hot surfaces e.g. turbo chargers * Like for like components not replaced e.g. contained fuel lines and hydraulic hoses that prevent leaks from spraying onto hot surfaces. 	<p> D12 - Fires on mine sites - V1</p> <p> D14 - Fixed plant and mobile equipment fires on surface coal mines - V1</p> <p> D18 - SA15-05-Water-truck-destroyed-by-fire</p> <p> D24 - SB16-02-Lead-acid-battery-explosions</p>	<ul style="list-style-type: none">  BI-02.02 Maintenance requirements cover all safety and operational systems on mobile plant  BI-02.07 Regular checking and maintenance of brakes, steering and tyres  BI-02.09 Regular checking and maintenance of alarms and monitors  BI-01.51 Skilled and experienced personnel are accountable for maintaining mobile equipment  BI-04.04 Site change management process apply to the introduction of new types and models of mobile equipment

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Series 2 Tables - Detailing Credible Failure Modes with links to Required Operating States (part)

Credible Failure Mode	Description	Related Required Operating State (ROS)s
Design – Credible Failure Modes		
CFM-DE-01 Liquid fuel loss of containment - design weakness	<p><i>During normal operations, there is a failure of reservoirs, hoses or lines containing fuel, hydraulics, lubrication, coolants etc. caused by:</i></p> <ul style="list-style-type: none"> <i>* Caused by rubbing, vibration, corrosion etc.</i> <i>* The released liquid is a fuel that can be ignited in its specified or particular state e.g. turbo charger, exhaust, electrical fault, atomised fluids at pressure etc.</i> <i>* Pressurised bearings which continue to feed fuel (oil) to turbo even after shut down of engine triggered</i> <i>* Gravity fed oil to turbo (continues to feed fuel (oil) after shut down of engine triggered)</i> <i>* Failure to consider the exposure of external components (e.g. fuel cap position, etc.)</i> <i>* The loss of containment is due to equipment or component design failure from OEM or third party supplier.</i> 	<p>🛡️ ROS-EF-01 Mobile plant design prevents interactions between flammable materials, fuel and ignition sources</p>
CFM-DE-02 Solid fuel present on mobile equipment - specification weakness	<p><i>During normal operations, fuel other than liquid is present and can be ignited including:</i></p> <ul style="list-style-type: none"> <i>* contact of components with a turbo charger, exhaust, electrical fault, etc.</i> <i>* the fuel is present through OEM or third party equipment or component design or design fault, this includes aftermarket retrofits e.g. combustible covers</i> 	<p>🛡️ ROS-EF-01 Mobile plant design prevents interactions between flammable materials, fuel and ignition sources</p>

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Credible Failure Mode	Description	Related Required Operating State (ROS)s
	<p><i>and guards on mobile equipment</i></p> <ul style="list-style-type: none"> <i>* no consideration of products of combustion of flammable components (e.g. FRAS products that produce CN gases)</i> <i>* batteries (on electrically powered vehicles) are flammable</i> <i>* Solid fuel hazard identification missed through - design and design specifications, audits, risk assessments, site acceptance etc.</i> 	
<p>CFM-DE-03 Fuel is introduced to mobile equipment - design weakness</p>	<p><i>During normal operations the equipment design does not prevent build ups of external fuel in mobile equipment, including:</i></p> <ul style="list-style-type: none"> <i>* hot component or nearby surfaces that allow accumulation of coal dust, sulphide ores, organic matter etc.</i> <i>* equipment is not designed to contain operating oils, fuels, etc.</i> 	<p>🛡️ ROS-EF-01 Mobile plant design prevents interactions between flammable materials, fuel and ignition sources</p>
<p>CFM-DE-04 Excessive heat is produced and not effectively contained/shielded from fuel sources during mobile equipment operation - design weakness</p>	<p><i>During normal operations, there are accessible hot surfaces above the ignition temperature of probable fuel sources, including:</i></p> <ul style="list-style-type: none"> <i>* Electrical failures such as jammed starter motors</i> <i>* Overheated cables or faults such as a cable short</i> <i>* Electrical fault around battery with damage to insulation, shorting of leads, and/or contact between live components and machine body</i> <i>* Alternator faults</i> 	<p>🛡️ ROS-EF-01 Mobile plant design prevents interactions between flammable materials, fuel and ignition sources</p>

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Credible Failure Mode	Description	Related Required Operating State (ROS)s
	<ul style="list-style-type: none"> <i>* Inappropriate cable routing proximate to flammable materials/fuels</i> <i>* Engine faults e.g. running backwards</i> 	
<p>CFM-DE-06 Fire suppression systems do not function or are inadequate - design fault</p>	<p><i>Caused by:</i></p> <ul style="list-style-type: none"> <i>* Fire suppression system design cannot easily extinguish a vertical fire</i> <i>* Lack of volume fuel source cannot be isolated, ignition source cannot be cooled</i> <i>* Poor positioning of pyro-tubes or suppression nozzles</i> <i>* Automatic deployment of fire suppressions or shut-down system does not trigger when required</i> <i>* Fire suppression does not enunciate requirement for deployment (no voice command)</i> 	<ul style="list-style-type: none"> 🛡️ ROS-EF-04 Local Response to fires or potential fires on mobile equipment - early detection with effective local response
<p>CFM-DE-31 New generation of mobile equipment - fire potential and pathways not recognized</p>	<p><i>The fire risks from new technology are not well understood or inadequately assessed, for example:</i></p> <ul style="list-style-type: none"> <i>* electric or part electric vehicles using downhill regeneration</i> <i>* next generation diesel engines</i> <i>* new technology for vehicle control and its integration with shutdown and suppression systems</i> <i>* remotely operated equipment etc.</i> 	<ul style="list-style-type: none"> 🛡️ ROS-EF-04 Local Response to fires or potential fires on mobile equipment - early detection with effective local response 🛡️ ROS-EF-01 Mobile plant design prevents interactions between flammable materials, fuel and ignition sources 🛡️ ROS-EF-02 Mobile plant is maintained to a schedule and to OEM standards. Specific fire prevention and mitigation checks are part of the maintenance process. There are no early operational failures

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Credible Failure Mode	Description	Related Required Operating State (ROS)s
		<ul style="list-style-type: none"> 🛡️ ROS-EF-03 Mobile plant is operated productively and safely within operating design limits, avoiding fire or potential fire incidents 🛡️ ROS-EF-05 Maintenance activities on or around mobile equipment do not cause fires 🛡️ ROS-EF-09 Effective Emergency Response beyond local response limits fire losses
<p>CFM-DE-32 Fire suppression system fails because of interface logic issues</p>	<p><i>Caused by:</i></p> <ul style="list-style-type: none"> * Automatic or manual system activation signal sent but not received by fire suppression system * Automatic or manual system activation signal sent and received by fire suppression system which activates but fails to suppress the fire because of a sequence issue i.e. cooling fans are still running 	<ul style="list-style-type: none"> 🛡️ ROS-EF-02 Mobile plant is maintained to a schedule and to OEM standards. Specific fire prevention and mitigation checks are part of the maintenance process. There are no early operational failures 🛡️ ROS-EF-04 Local Response to fires or potential fires on mobile equipment - early detection with effective local response
<p>CFM-DE-33 Fire suppression systems design, configuration and installation outsourced to third party - provided to operator without specification or OEM oversight.</p>	<p><i>After build fitting of a fire suppression system does not adequately address the fire risk.:</i></p> <ul style="list-style-type: none"> * Information about relative fire potential during operations is not provided by OEM * Vulnerable install i.e. suppression system activators are disabled by the fire * Suppression agent pipe runs are susceptible to mechanical damage * Detection misses high risk areas * Mixed compartment system installed 	<ul style="list-style-type: none"> 🛡️ ROS-EF-02 Mobile plant is maintained to a schedule and to OEM standards. Specific fire prevention and mitigation checks are part of the maintenance process. There are no early operational failures ROS-EF-04 Local Response to fires or potential fires on mobile equipment - early detection with effective local response

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Credible Failure Mode	Description	Related Required Operating State (ROS)s
	<i>Operator has an inadequate 'acceptance to site' or approval for operations process that does not identify and fix out of specification issues</i>	

SAMPLE

SERIES 5 Tables - Providing Details of Business Inputs that prevent or mitigate Mobile Equipment Fires

Business inputs for Equipment acceptance, maintenance, servicing and pre start checks

- Approval of equipment use on site
- Maintenance and servicing
- Pre use checks

Table 5.3 Fit for Purpose Equipment Business Inputs covering Equipment acceptance, maintenance, servicing and pre start checks (part)

Business Input	Specification	Implementation	Monitoring
<p>BI-02.01 Introduction of equipment to site process</p>	<p>Why - To confirm that only plant (including mobile equipment and monitoring systems) which meets site requirements is used on site.</p> <p>Where - In any location where fixed or mobile equipment is used to perform a task.</p> <p>When - Whenever equipment is required to be brought to or deployed on site.</p> <p>Requirements:</p> <ol style="list-style-type: none"> 1. Equipment intended to be brought to site is advised to the site maintenance department well before it is due to be deployed on site. 2. Contractual requirements which allow for inspections to occur prior to acceptance (for equipment purchases or hires) and prior to intended deployment on site (for service contracts), note: acceptance inspections can be completed before arrival at site e.g. pre shipping, at OEM factory, etc. 3. Information on site requirements (detailed specifications for mobile plant) are provided to suppliers, contractors and other relevant third parties well ahead of any plant delivery to site. 4. Operability and maintainability risk and control assessments are conducted on new types of plant being introduced to the site to confirm and/or 	<ol style="list-style-type: none"> 1. Trainers and Superintendents reinforce the requirements for any equipment arriving on site. 2. Superintendents and others arranging for equipment to be brought to site involve the relevant engineering personnel and make appropriate arrangements with third parties (e.g. contract companies) for their equipment to be checked and included in site asset registers prior to any site deployment. 3. Engineers or nominated trades workers inspect all equipment and associated paperwork to confirm the incoming plant meets site requirements - and pass on completed Intro to Site paperwork to maintenance planners and others. 4. Maintenance planners raise work orders for incoming plant in line with maintenance strategies meeting site requirements. 	<ol style="list-style-type: none"> 1. Regular auditing of the asset register with tracking of any improvement opportunities identified. 2. Monitoring and tracking of the close out of identified maintenance tasks - with a priority given to safety related components. 3. Confirming checks that equipment on site continues to meet relevant site requirements and guidance standards is commissioned by senior engineering decision makers and the results tracked by senior site personnel.

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Business Input	Specification	Implementation	Monitoring
	<p>inform site procedures and systems are in place to support ongoing safe and productive operation of the plant.</p> <ol style="list-style-type: none"> 5. Site requirements are communicated with providers of the plant prior to its arrival on site. Records should be prepared of conformance of the plant by the provider (which may require them to make modification off site) so they can be critically reviewed when the plant arrives. 6. Nominated members of the site maintenance/engineering team should tag any incoming plant unserviceable until confirming checks are made of completed records and to complete and record an appropriate series of checks on the item of plant to allow for: <ul style="list-style-type: none"> • Completed paperwork is submitted to maintenance planners (to raise an asset and apply an appropriate maintenance strategy); • Accompanying certificates and plant safety file information to be included in the information management system; • Formal removal of the out-of-service (or similar) tag and transfer of control of the plant to operational department workers. 7. Systems, particularly those with a safety related function, are formally proof tested as part of commissioning to confirm they will meet site requirements for alarm/trip points' detection and sensitivity. 8. Regularly during the time the plant is on site (typically as part of the 1,000 hour service) or whenever an approved item of equipment returns to the site after an absence, a nominated 		

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Business Input	Specification	Implementation	Monitoring
	<p>tradesperson conducts the site based inspection on the item of equipment to confirm that the item continues to meet site requirements.</p> <p>9. Inspection requirements should match the type of plant being introduced.</p> <p>10. Fixed plant installations are formally commissioned - in line with engineering and OEM guidance and the results of the commissioning process are included in the maintenance strategy and Plant Safety File for this installation/facility.</p>		
<p>BI-02.02 Maintenance requirements cover all safety and operational systems on mobile plant</p>	<p>Maintenance strategies are developed for all mobile and related plant with work orders generated in line with OEM requirements for inspections, replacement and lubrication of components. Key work orders are identified for safety related systems to extend the inspections to proof tests - particularly for brakes and steering systems. Maintenance systems should be in place that store and manage maintenance information,</p> <ul style="list-style-type: none"> • planned inspections • Servicing • Analysis and reporting on equipment and maintenance performance. • Mobile and fixed plant is maintained according to OEM recommendations • Defects are recorded, reported, managed (if necessary mobile equipment is taken out of service) and scheduled for repair • Post maintenance equipment inspection and run up before being returned to service 	<p>Maintenance planners issue work orders for mobile plant in line with confirmed strategies. Maintenance workers conduct work order tasks in line with site requirements (which may extend beyond OEM procedures). Completed work order records are returned to the maintenance planners.</p>	<p>Reports on maintenance work order close out are prepared by maintenance planners and more senior personnel on site review the status of safety related work orders.</p>
<p>BI-02.03 Brakes, Steering, Tyres, Cabins covered by processes for confirming</p>	<p>Mobile equipment specifications in place which include a requirement for appropriate cabin integrity, brakes, steering</p>	<p>Ordering / selection of equipment includes requiring brakes, steering and running gear meeting site</p>	<p>Maintenance planners review Introduction to Site forms and add work</p>

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Business Input	Specification	Implementation	Monitoring
that new to site vehicles meet site specifications	and tyres that are confirmed as meeting site requirements during the introduction to site process.	requirements. Equipment on site passes through a rigorous Introduction to Site process - which confirms that key systems - such as brakes, steering and running gear are in place and meet site specifications.	orders for key systems - brakes, steering, tyres and running gear maintenance to the new site asset (on the Computerised Maintenance management System).
BI-02.07 Regular checking and maintenance of brakes, steering and tyres	Maintenance strategies related to brakes, steering, tyres and tyres are in place for all vehicles on site - with regular visual checks, measurements (with tolerances), and replacement of components scheduled based on OEM recommendations and identified site specific risks.	Work orders for equipment on site are completed in a timely manner - and brakes, steering, tyres and running gear are given a higher priority - with potentially more frequent proof testing and replacement.	Maintenance planners close out work orders when confirmed as completed and prepare regular status reports on work order status for equipment on site.
BI-02.08 Fire suppression system is integrated into machine operation	An acknowledgement and override is required to move mobile equipment if the fire detection and suppression system is operable e.g. isolated or has been discharged.		
BI-02.11 An effective maintenance strategy for electrical components	Manufacturers/suppliers provide guidance information on recommended maintenance strategies for supplied plant. These strategies are based on equipment performance, risk analysis of components and systems, and MTBF/criticality considerations. Requirements for proof testing of safety related elements of the plant are identified and more frequent inspection, component change outs, etc. are included as part of the OEM/Supplier strategy recommendations.	Change out strategies/procedures are provided for various components that include measures to prevent heating and/or fires.	Work orders are returned to competent persons who prepare follow up tasks (for subsequent maintenance) and status reports for senior decision makers.
BI-02.12 Serviced and checked fire extinguishers on mobile equipment	Portable power fire extinguishers two appropriately sized portable fire fighting extinguishers (e.g. 9 kg ABE) installed on mobile equipment	Through acceptance inspection	Daily checks, weekly inspections and as required inversion to avoid powder compaction.

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Business Input	Specification	Implementation	Monitoring
<p>BI-02.13 Routine tyre inspection</p>	<p>Earth moving equipment tyres are regularly inspected by:</p> <ul style="list-style-type: none"> • Operators as part of equipment pre-use checks • Tyre specialists <p>Equipment with low pressure or damaged tyres is removed from service.</p>	<p>As per tyre maintenance schedule</p>	<p>Tyre condition reports including service life monitoring</p>
<p>BI-02.22 Design of hydrocarbon and fuel tanks are maintainable and prevent leaking</p>	<p>Designs of tanks consider relevant factors, including:</p> <ul style="list-style-type: none"> • Making allowance for refuelling • Draining process allowed for • Location on the item of mobile plant in a manner that minimises potential for damage • Devices that prevent over-pressurisation of the tank do not allow for hydrocarbon release in the event of travel on inclines or in a roll-over situation 	<p>Specifications are documented and confirmed by providers (suppliers, hirers and contracted parties) as part of any intended supply of mobile plant. Confirmed specifications are transferred to Introduction to site check lists.</p>	<p>Maintenance strategies are developed by competent personnel on the site to inspect and maintain any tanks on a regular basis (at a minimum in line with OEM recommendations).</p>
<p>BI-02.23 Engine compartments are cleaned to prevent fuel build up</p>	<p>Engine compartments are maintained to minimise accumulation of foreign material that can lead to the creation of a fuel source or lead to an accumulation of heat</p>		
<p>BI-02.31 Operator pre-start checks include brakes, steering, tyres and running gear</p>	<p>Requirement for Vehicle Operators / co-workers to check the general condition of brakes, steering, tyres and other running gear. Start up checks include brake and steering warning systems.</p> <p>Based on OEM recommendations, operator pre-start checks are required before using mobile equipment that require</p> <ul style="list-style-type: none"> • Visual inspections of the engine bay for signs of leaks and build up of combustible or flammable liquids or solids such as fuel, hydraulic fluids or residue coolants. <p>The results of pre-start checks, including any defects, should be recorded in the maintenance system and addressed.</p>	<p>All workers should be trained or instructed in pre-start checks Pre-start forms confirming status of brakes, steering, tyres and running gear completed by Vehicle Operators.</p>	<p>Supervisors monitor specific activities such as vehicle operator's pre starts and mentor / reinforce control support activities as required. Maintenance planners review Pre-start forms and raise work orders as required. The results of pre-start checks, including any defects, should be recorded in the maintenance system and addressed. ♦</p>

Business Input	Specification	Implementation	Monitoring
<p>BI-02.60 Effective Hot work Processes</p>	<p>Hot work includes the use of thermal cutting equipment, grinding equipment, arc-welding equipment, heating devices, naked flames or mechanical friction devices. Work in designated hot work areas such as a welding bay in an underground workshop.</p> <p>Any hot work in other areas should be controlled through hot work procedures and associated permits.</p> <p>For hot work in any part of a mine outside a designated hot work area, a hot work permit system should be applied. The system should be based upon procedures that include:</p> <ul style="list-style-type: none"> • risk assessment of the area • inspection of the equipment for potential fuel source before commencing work • removal of any flammable products before commencing work • provision of fire extinguishers and thermal blankets • adequate ventilation flow • use of an observer or fire-watch, where required • inspection and monitoring of the equipment and work area after work has been completed • removal of all gas cylinders following the completion of hot work • use of an appropriate permit system • sign-off by an appointed person 		

Table 5.4 Operating Environment Business Inputs

Business Input	Specification	Implementation	Monitoring
BI-03.02 Operators follow site parking requirements	Procedures in place for parking that take into account mobile equipment fires or potential fire situations	Training and assessment in parking requirements for Vehicle Operators	Supervisors monitor parking activities of Vehicle Operators - confirming their activities meet site requirements.
BI-03.03 Effective coal/flammable dust suppression systems	Sites with flammable dust include requirements for mobile plant including: <ol style="list-style-type: none"> 1. No or limited surfaces that are able to accumulated dust near hot surfaces (during operation or equipment fault states). 2. Dust suppression systems that limit the amount of dust that could accumulate on mobile plant. 3. Requirements for pre-shift/through-shift checks and as required cleaning of mobile plant locations near hot surfaces. 	Specification for site and Introduction to site processes require and confirm that flammable dust management systems are in place on mobile plant and are checked (if spray related) for function. Maintenance strategies include work order requirements for flammable dust management components/systems. Work orders for flammable dust management systems are issued to and executed by trades workers in line with maintenance strategies. Operational workers conduct required pre/through shift inspections and cleaning tasks.	Completed introduction to site processes are reviewed by competent persons and information transferred to maintenance systems and plant safety files as required. Competent persons receive completed work orders and prepare reports for more senior decision makers on the status of important tasks on deployed plant.
BI-03.04 Lightning TARP	Procedures in place for storm situations Develop and implement a process to minimise potential for fire from lightning strikes <ul style="list-style-type: none"> • Monitor lightning activity using meteorological forecasts and other early warning detection systems • Lightning protection or diversion systems should be installed in accordance with appropriate standards (e.g. National Fire Protection Agency 780 2011 Standard for 	Training and assessment in requirements for Vehicle Operators during storms	Supervisors monitor activities of Vehicle Operators during storms - confirming their activities meet site requirements.

Examples from the EMESRT CFw Equipment Fires Ver1 Release - May 2019

Business Input	Specification	Implementation	Monitoring
	<p>Installation of Lightning Protection Systems; AS/NZS 1768 2007 Lightning Protection)</p> <ul style="list-style-type: none"> • Provide timely communications to allow sufficient time for all exposed site personnel to seek appropriate safe shelter • Place equipment in protected area away from fuel sources (i. stop damage; ii. Stop spread to fleet) • Instigate awareness training for workers that highlights the risks of lightning strikes • Develop a trigger action response plan (TARP) for lightning and electrical storms that outlines responses to a storm at certain distances away from the mine (e.g. a staged response depending on distance) • Procedure for the use and protection of explosives in known lightning conditions 		
<p>BI-03.05 Purging of fuel tanks before hot work</p>	<p>Colour coding, labelling</p>		
<p>BI-03.06 Burst protection on hoses</p>	<p>Hoses with liquid fuel have burst detection i.e. if a hose fails fuel leaks are contained.</p>		
<p>BI-03.07 Refuelling Practices - trained personnel follow site refuelling procedures</p>	<p>Operating sites have refuelling procedures covering functions such as:</p> <ul style="list-style-type: none"> • Operation of fuel transfer systems • Refuelling of vehicles, equipment and fixed plant • Replacement or changing of fuel cells or storage tanks • Housekeeping in refuelling bays inspection of fire suppression systems and fire extinguishers • Emergency procedures including spill response • Refuelling outside refuelling bays must be authorised by the underground manager 		