HOT WORK MANAGEMENT

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1.0 SCOPE

This document provides recommendations for preventing hot work fires and explosions. The guidance within this document is applicable to all facilities where hot work is conducted on a temporary or routine basis.

Refer to other FM Global data sheets for prevention of hot surface and open-flame ignition source hazards associated with heated processes or utility equipment such as ovens/dryers, furnaces, kilns, and boilers.

1.1 Hazards

1.1.1 Hot Work Fire/Explosion Prevention and Fire Mitigation

All hot work fires and explosions are preventable. A hot work fire or explosion is the result of inadequate hot work management allowing ignition sources to come into contact with combustible, ignitable, or flammable material. The most effective way to prevent a hot work fire or explosion is to aggressively pursue alternative cold work methods. The next best way is to relocate the work to a hot work designated area. If neither option is possible, then removing and/or isolating combustible, ignitable, or flammable materials located within the hot work area or equipment is recommended.

Unfortunately, the implementation of the necessary hot work fire prevention methods are not entirely reliable. To complement prevention efforts, a hot work management program should also contain fire mitigation measures to reduce the consequences of a possible hot work fire. Loss history has shown the vast majority of hot work fires occur during the work or within the first hour following work completion, but more severe hot work fires occur in unprotected areas of the facility where protection systems are either not installed or impaired.

To mitigate the consequences of a hot work fire, a continuous fire watch should be provided in the hot work area during work and immediately following work. Also, hot work that requires a permit should be avoided in unprotected areas whenever possible; otherwise, additional required precautions should be implemented.

1.1.2 Additional Resources

For additional information on the hazards associated with ineffective hot work management, refer to the following FM Global resources:

- Hot Work Management Kit with permit holster, permits, and brochures (P9601)
- *Hot Work Permit System Kit* with permit holster and permits (P9311)
- *Hot Work Permit* (F2630)
- *Hot Work Permit App Brochure* (P12445j)
- *Don't Get Burned By Hot Work* (P9802)
- *Pocket Guide to Hot Work Loss Prevention* (P9602)
- *Understanding the Hazard: Hot Work* (P0032)
- *Understanding the Hazard: Contractor Management* (P0110)
- *Managing Hot Work Online Training Flyer* (P0686a)
- *Advancing Hot Work Skills Online Training Flyer* (P12062)
- *Managing Hot Work Online Training Flyer* (P08109e)

1.2 Changes

July 2018. Interim revision. A sample Hot Work Permit was updated (Appendix D). Construction and occupancy factors for post-work fire watch and monitoring periods (page 3) were added.

2.0 LOSS PREVENTION RECOMMENDATIONS

Use FM Approved equipment, materials, and services whenever they are applicable and available. For a list of products and services that are FM Approved, see the *Approval Guide,* an online resource of FM Approvals.

2.1 Introduction

Improperly managed hot work remains a leading cause of large fires and explosions. Based on a review of FM Global loss history, the following conclusions were drawn regarding key factors in hot work losses:

A. Failing to identify and isolate combustible construction in the hot work area increases the likelihood and severity of a hot work fire.

B. Failing to identify and isolate combustibles in a hot work high-risk area increases the likelihood and severity of a hot work fire.

C. In-service fire protection systems significantly reduce the severity of a hot work fire.

D. The overwhelming majority of hot work fires occur while the work is being done or within 60 minutes of completion, highlighting the importance of a fire watch both during and following hot work.

The primary focus of a hot work management program should be on pursuing cold work alternatives or, failing that, relocating the work to a hot work designated area. If hot work is unavoidable, it is vital to remove or isolate combustible materials. Regardless of size, any hot work fire or explosion should be viewed as a failure of the hot work management program.

The post-work fire watch and/or fire monitoring period should be considered a secondary layer of protection against the uncertainty of identifying and controlling all combustible materials within the hot work area. The appropriate post-work watch and monitoring duration requires judgment based on the factors present within the hot work area, including confidence in being able to identify and remove or isolate combustible materials; the type and quantity of combustible materials present within the hot work area (i.e., combustibles that could be removed and are capable of smoldering or of a sufficient quantity to support a large uncontrolled fire); and the presence of automatic fire protection. If the hot work area is unprotected (e.g., unsprinklered), post-work watch and monitoring along with manual fire-fighting required precautions become more critical.

At no time should any length of post-work watch and monitoring be considered a substitute for properly preparing and maintaining the hot work area or equipment. A hot work management process should always begin with and focus on controlling combustibles in the hot work area.

2.2 Hot Work Management Program

2.2.1 Establish a formal policy statement on hot work management. At a minimum, cover the following in the statement.

A. Identify the program owner.

B. List the hot work operations managed under the program. The list should include operations that introduce or produce high-energy hot work ignition sources (e.g., metal welding, cutting, grinding). Low-energy hot work ignition sources may also be managed under the program (e.g., use of unrated electrical equipment in hazardous/classified electrical areas or electrical soldering irons).

C. Define the following areas within the facility:

1. Hot work designated areas (Section 2.4)
2. Hot work production areas (Section 2.4)
3. Hot work high-risk areas or operations (Section 2.5)
4. Hot work areas categorized per Section 2.5.4

D. Define the requirements for hot work permitting, including permit authorization; permit expiration; and contractor supervision. Include these requirements in the policy statement or refer to the pertinent standard operating procedures (SOPs).

E. Define the requirements for investigating and documenting all hot work fires and explosions regardless of size and/or damage, and hot work near-miss incidents. Document corrective actions resulting from the investigation.

F. Define the requirements for retaining hot work documentation.

G. Define the requirements for training employees and contractors on the hot work management program, including scope and frequency. Provide manual fire extinguishers throughout the fixed hot work station.

H. Define the requirements for auditing the hot work management program, including scope and frequency.

I. Have the program endorsed by facility senior management.

2.2.1.1 When applicable, incorporate standard operating procedures (SOPs) for hot work management into the facility's International Organization for Standardization (ISO) certification. ISO certification requirements often align with administrative controls recommended in Section 2.2, including policy statement, document retention, management of change, and auditing.

2.2.1.2 When multiple categorized areas are present, ensure the appropriate fire watch and fire monitoring periods are provided in each by incorporating the following administrative controls:

A. Clearly define the boundaries of each categorized area in the policy statement and procedures. Preferably, develop a site plan and/or building plan showing the boundaries of the various categorized areas.

B. Train permit authorizers and personnel performing hot work to recognize the boundaries of the categorized areas, and how changes to the areas are communicated and updated.

2.2.2 Conduct initial and annual refresher training for all employees and contractors involved in the hot work management program.

2.2.2.1 Train employees working in or inspecting hot work designated areas or production hot work areas to maintain the work area free of combustible materials and to contain hot work ignition sources within the work area.

2.2.2.2 At a minimum, train employees and contractors involved with hot work permitting (including permit authorizers, personnel performing hot work, fire watches, and fire monitors) in the following subjects:

A. Implementation and control of required precautions, and how to escalate any problems identified with the required precautions

B. Inspecting the hot work area for fire-safe conditions and, if a fire is detected, notifying emergency contacts before making any attempt to extinguish the fire

C. Use of fire extinguishers or firefighting hose if expected to use this equipment in response to a fire

2.2.3 Retain hot work management records for program auditing. At a minimum, retain the following records:

A. Completed forms, including hot work designated area inspections and hot work permits

B. Reports on hot work fire and explosions, including root cause and corrective action to prevent a reoccurrence

C. All hot work management program audit findings

2.2.4 Conduct audits of the hot work management program. Establish an audit frequency based on facility conditions, such as previous audit findings and hot work-related fires and explosions. At a minimum, conduct audits at least annually. Include the following in the audits:

A. Completed forms, including hot work designated area inspections and hot work permits from different post-work categorized areas.

B. Training records for contractors and employees.

C. Incident log and investigation reports for hot work fires and explosions as well as near misses. Determine the status of any resulting corrective actions.

D. Facility changes that may impact the hot work management program, hot work designated areas, permitting procedures, or hot work high-risk areas (e.g., physical or personnel changes).

2.2.5 Manage contractors in accordance with Data Sheet 10-4, *Contractor Management.* Ensure contractors are familiar with the facility-specific hazards and are supervised during their work.

2.3 Hot Work General Practices

2.3.1 When planning hot work that requires a permit, begin the pre-work safety review by considering the following two options:

A. Avoid hot work. Consider using an alternative cold work method. Refer to Section 3.1.3 for information on alternative cold work methods.

B. Relocate the work to a hot work designated area protected in accordance with Section 2.4.

2.3.2 If hot work that requires a permit is unavoidable, use a hot work permit system meeting the requirements of this data sheet and/or the local authority having jurisdiction, whichever is more stringent.

2.3.3 Maintain hot work equipment in good operation per the equipment manufacturer's guidelines.

2.3.4 Ensure hot work equipment is properly installed and arranged prior to initiating work. For example, provide appropriate electrical grounding for work surfaces to prevent stray currents during arc welding; protect piping and hoses conveying flammable or shielding gases used for welding or cutting; and restrain compressed gas cylinders used for welding or cutting.

2.3.5 When hot work is routinely conducted as part of production, protect the production area as a hot work designated area in accordance with Section 2.4.

2.4 Hot Work Designated Areas (Hot Work Permit Not Required)

2.4.1 Location and Construction

2.4.1.1 Do not assume outdoor locations are by default hot work designated areas because combustible construction and combustible material (yard storage) may be present. Apply the following recommendations to outdoor hot work designated areas when appropriate.

2.4.1.2 Enclose hot work designated areas in a cutoff room. Locate the cutoff room separate from high-risk areas that may contain commodity storage, ignitable liquid, flammable gas/vapor, and or combustible dust/lint. When fully-enclosing the hot work designated area in a cutoff room is not feasible, implement one of the following options to protect open walls or ceiling as shown in Figure 1.

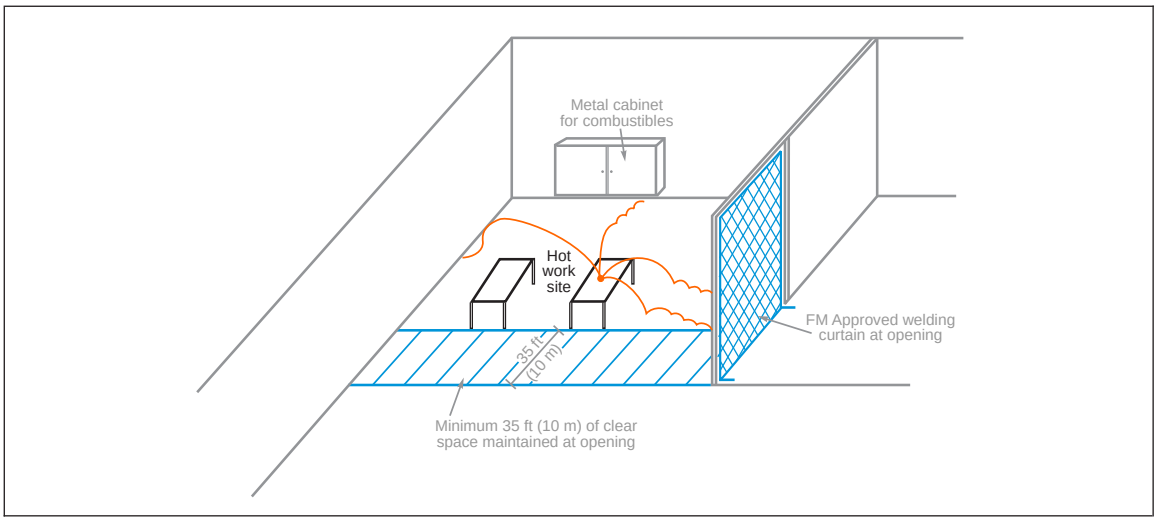


Fig. 1. Hot work designated area

A. Employ temporary barriers, such as FM Approved welding curtains or blankets, to control ignition sources at unprotected openings in the cutoff rooms (e.g., open doorways or partial wall heights or lengths). Provide sufficient overlap and securement of the welding curtains or blankets. Label unprotected openings using signage.

B. Maintain a minimum 35 ft (10 m) clear separation distance at the open sides of the cutoff room. Label this separation distance using permanent marking (e.g., strips on the floor) and signage.

2.4.1.3 Construct cutoff rooms enclosing hot work designated areas of noncombustible construction. Install wall and ceiling/roof building assemblies that contain only noncombustible building materials. FM Approved Class 1 building materials are considered noncombustible.

2.4.1.4 Install facing materials on walls and ceilings that resist impact damage (e.g., corrugated steel paneling). Limit the use of brittle materials that are prone to mechanical impact damage (e.g., gypsum board).

2.4.1.5 Seal joints between floors, walls, and ceilings/roofs to prevent hot work ignition sources from escaping the designated area. Use FM Approved fire-stop materials.

2.4.2 Occupancy

2.4.2.1 Maintain hot work designated areas free of combustible, ignitable, and flammable materials. If required for work, store combustible materials in metal cabinets, and ignitable and flammable materials in FM Approved storage cabinets for flammable and combustible liquids.

2.4.2.2 Design and install HVAC systems per Data Sheet 7-78, *Industrial Exhaust Systems.* Incorporate the following into the system design:

A. Provide a dedicated HVAC system serving the hot work designated area.

B. Use noncombustible ductwork and insulation.

C. If particulate filtration is required, use an FM Approved Class 1 air filter.

2.4.3 Protection

2.4.3.1 Provide automatic sprinkler protection within hot work designated areas when the cutoff room wall or ceiling/roof assemblies contain combustible construction. Design and install sprinkler protection based on the occupancy within the room.

2.4.3.2 Provide supplemental fire extinguishers within hot work designated area (i.e., in addition to those extinguishers required by local codes). Ensure the extinguishers are rated and sized appropriately for the hazard. Inspect, test, and maintain fire extinguishers per Data Sheet 2-81, *Fire Protection System Inspection, Testing, and Maintenance.*

2.4.4 Operation and Maintenance

2.4.4.1 Conduct inspections of hot work designated areas to maintain the work area free of combustibles per Section 2.4.2.1, and contain hot work ignition sources within the work area per Section 2.4.1. Conduct inspections at least monthly. Maintain records for program auditing per Section 2.2.3.

2.5 Hot Work Permit-Required Areas (Hot Work Permit Required)

2.5.1 Permit Authorization and General Required Precautions

2.5.1.1 Assign the following responsibilities to hot work permit authorizers:

A. Avoid hot work that requires a permit whenever possible. Pursue cold work alternatives or relocate the work to a hot work designated area. Refer to Section 3.1.3 for a discussion of cold work alternatives.

B. If hot work that requires a permit is unavoidable, use a hot work permit system that meets the recommendations in Section 2.5.

C. Coordinate hot work that requires a permit with fire protection system impairment permits (i.e., fire protection systems taken out of service). Ensure permit authorizers for hot work permits and impairment permits communicate planned work and active permits. Ideally, post copies of active hot work permits and impairment permits in a visible, centrally located area (e.g., maintenance office). Avoid conducting hot work that requires a permit when fire protection systems are impaired. If permit-required hot work is unavoidable in areas with impaired protection systems or in unprotected areas, refer to Section 2.5.2.1.3.

D. Limit permit authorization to a single shift. Permit extensions at shift change may be acceptable provided a permit authorizer reviews the permit, re-verifies required precautions are in place, provides a new expiration date, and re-signs the permit.

E. Verify the required precautions are in place prior to authorizing the permit and initiating work. Confirm the proposed hot work area is properly prepared and hot work will be conducted in a fire-safe manner.

F. Conduct a final check of the hot work area for fire-safe conditions after the post-work fire watch and/or fire monitoring periods have concluded. Preferably, have a permit authorizer conduct the final check; however, fire watch and fire monitor personnel should be sufficiently trained to conduct the final check as well. Maintain completed hot work permits for auditing per Section 2.2.3.

2.5.1.2 Verify hot work equipment is operable and arranged per Sections 2.3.3 and 2.3.4.

2.5.1.3 If the proposed work is to be conducted in a hot work high-risk area, additional required precautions may be warranted due to the greater likelihood and/or consequence of fires or explosions. Refer to Section 2.5.2 for a discussion of several hot work high-risk areas/operations.

2.5.2 Required Precautions Before Hot Work

2.5.2.1 Protect the Hot Work Area

2.5.2.1.1 Verify automatic fire protection systems (e.g., sprinkler systems) are in service if provided.

2.5.2.1.2 Verify onsite water supplies serving fire protection systems are in service (e.g., pumps in automatic mode and suction tanks full), if provided.

2.5.2.1.3 Verify there are no active or planned fire protection system impairments near the hot work area scheduled to occur during work, or during the post-work fire watch and monitoring periods. If protection is impaired or not provided and hot work that requires a permit is unavoidable, do the following:

A. Delay the work until protection is restored.

B. Treat the unprotected area as a hot work high-risk area and provide additional required precautions, which may include extra measures to ensure combustibles have been identified and removed or isolated; laying charged firefighting hoses and stationing trained firefighting personnel in the hot work area; increasing post-work watch and monitoring periods from Section 2.5.4; and/or requiring permit authorization by senior management.

2.5.2.1.4 Provide manual firefighting equipment, including supplemental fire extinguishers (i.e., in addition to those extinguishers required per local codes) and/or, when necessary, firefighting hose laid out and connected to a closed hose valve. Ensure fire extinguishers are rated and sized appropriately for the hazard. Inspect the equipment prior to initiating the work. Inspect, test, and maintain fire extinguishers per Data Sheet 2-81, *Fire Protection System Inspection, Testing, and Maintenance.*

2.5.2.2 Prepare the Hot Work Area

2.5.2.2.1 Define the hot work area as 35 ft (10 m) horizontally from the hot work site and 15 ft (5 m) above the hot work site as shown in Figures 2, 3, 4, and 5. Consider extending the hot work area horizontally from 35 ft (10 m) to 50 ft (15 m) if conducting elevated hot work or working in a drafty environment such as outside on a windy day or indoors near a ventilation exhaust louver. Consider extending the hot work area vertically above the hot work site from 15 ft (5 m) to 35 ft (10 m) if torch cutting, radial grinding/cutting, or electric arc welding.

2.5.2.2.2 Remove combustible equipment, storage, and similar materials from the hot work area. If combustibles are non-moveable (e.g., combustible construction), isolate non-moveable combustible materials from ignition sources using one of the following options. Do not use wet-down as an alternative to isolating combustible materials.

A. Shield non-moveable combustible materials with FM Approved welding pads or blankets using the appropriate application as discussed below:

1. Welding pads are intended for use where the hot work exposure is severe. FM Approved pads are designed to resist burn-through and thermal conduction when positioned in close proximity to the hot work site in a horizontal orientation and exposed to molten metal contact.

2. Welding blankets are intended for use where the hot work exposure is moderate. FM Approved blankets are designed to resist burn-through and thermal conduction when positioned in close proximity to the hot work site in a horizontal or vertical orientation and exposed to sparks, flames, and heat. Blankets may not resist molten metal burn-through.

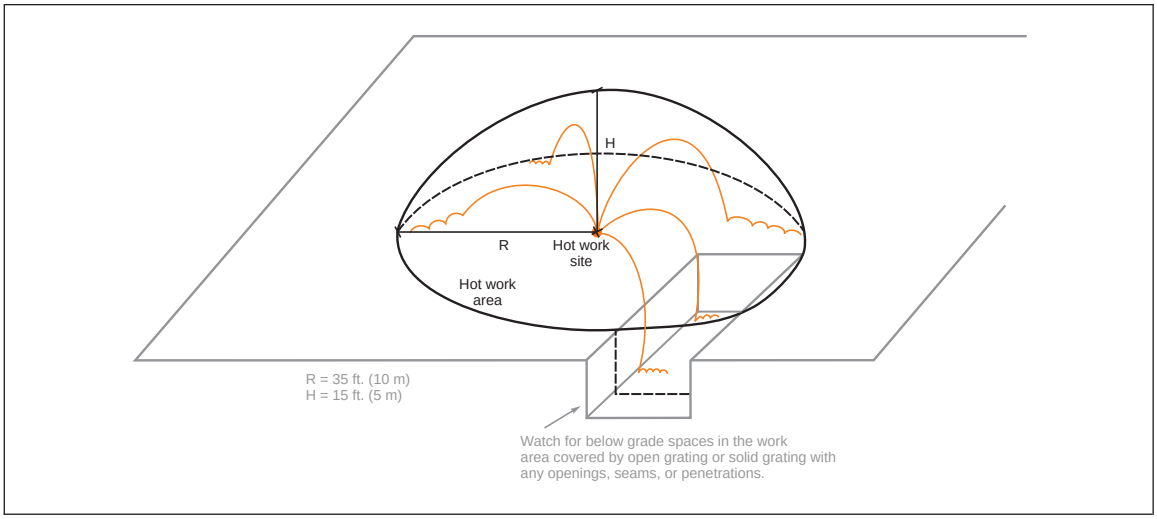


Fig. 2. Hot work permit-required area with single hot work site

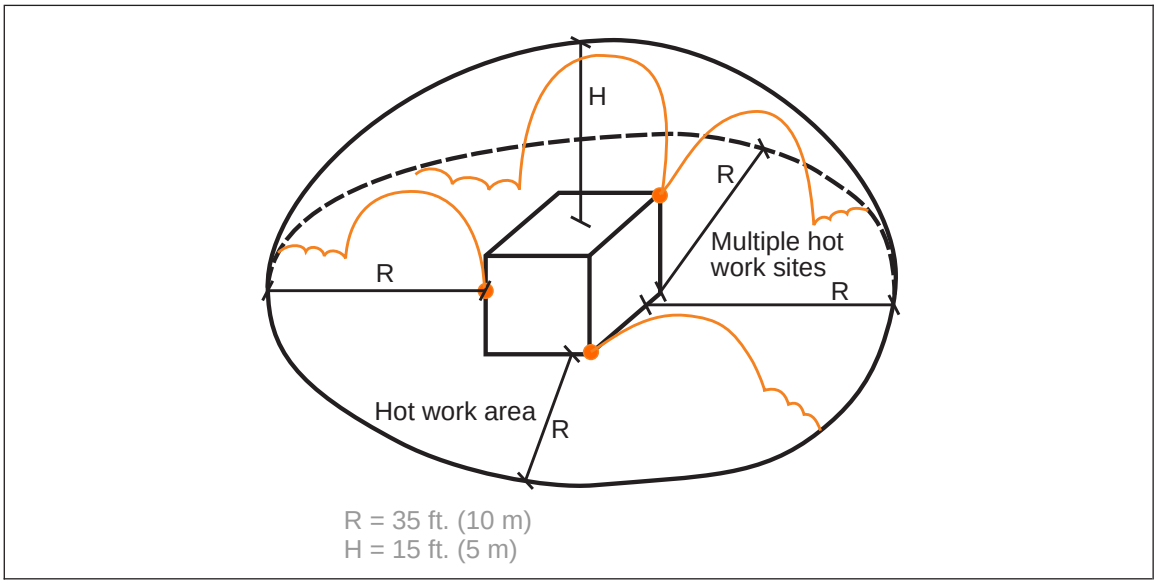


Fig. 3. Hot work permit-required area with multiple hot work sites

B. Contain hot work ignition sources using FM Approved welding pads, blankets, or curtains using the appropriate application as discussed below:

1. Welding pads are intended for use where the hot work exposure is severe. FM Approved pads are designed to resist burn-through and thermal conduction when positioned in close proximity to the hot work site in a horizontal orientation and exposed to molten metal contact.

2. Welding blankets are intended for use where the hot work exposure is moderate. FM Approved blankets are designed to resist burn-through and thermal conduction when positioned in close proximity to the hot work site in a horizontal or vertical orientation and exposed to sparks, flames, and heat. Blankets may not resist molten metal burn-through.

3. Welding curtains are intended for use where the hot work exposure is mild. FM Approved welding curtains are designed to resist burn-through or deformation when oriented vertically and positioned distant from sparks and flames.

4. Ensure seams between multiple pads, blankets, and/or curtains overlap sufficiently and openings at the bottoms of curtains are covered to prevent hot work ignition sources from escaping.

2.5.2.2.3 Remove combustible accumulations (debris, dust/lint, or residues) and pooling ignitable liquid (due to spills or leaks) from the hot work area. Thoroughly inspect the hot work area for accumulations in spaces hidden from sight such as in trenches or pits, underneath equipment, within partially-enclosed equipment, and atop cable trays, ductwork, or suspended ceilings. Perform the appropriate housekeeping activities to remove combustible accumulations and pooling ignitable liquid. Do not use wet-down as an alternative to removing combustible accumulations.

2.5.2.2.4 Isolate potential sources of flammable gas, ignitable liquid, and/or combustible dust/lint that may be released into the hot work area during work. Conduct a job safety analysis to identify sources of these materials, and to determine the appropriate isolation method. Typically, isolation starts with a minimum of de-energizing the equipment, but may also include blocking, draining, and purging equipment. Consider the following when isolating sources of flammable gas, ignitable liquid, and/or combustible dust/lint:

A. When a more-reliable blocking method is warranted, consider a double-block and vent valve arrangement, or physically disconnecting material sources by temporarily installing a pipe blank, cap, or plug.

B. When a less-reliable blocking method is used due to a lack of available options (e.g., a single-block valve), consider performing frequent checks or constant atmosphere monitoring to verify adequate isolation as discussed in Section 2.5.2.2.5.

C. When draining and purging is warranted, ensure all low-points are identified and verified clear prior to work.

D. Use safety programs such as lock-out tag-out, confined space entry, and line-breaking.

2.5.2.2.5 Test the hot work area for flammable vapor/gas prior to work and as-needed during work. When conducting atmosphere monitoring, immediately stop work if the atmosphere exceeds 1% of the lower explosive limit (LEL).

2.5.2.2.6 Protect or shut down ventilation and conveying systems in the hot work area. These systems may contain combustible material or transport hot work ignition sources outside the hot work area to downstream combustible accumulations or filters. If ventilation is needed for an enclosed hot work site, provide the following safeguards:

A. Use a temporary ventilation system constructed of noncombustible components and remove air filters. If particulate filtration is needed, use an FM Approved Class 1 air filter.

B. If negative ventilation is used, extend the hot work area to include the area around the fan discharge.

C. If positive ventilation is used, ensure the airflow does not disperse hot work ignition sources outside the hot work area as discussed in section 2.5.2.2.1 or compromise the arrangement of hot work blankets and curtains as discussed in section 2.5.2.2.2.

2.5.2.2.7 If one of the following conditions exists, extend the hot work area to include the opposite side of a building assembly (i.e., floor, wall, ceiling, or roof):

A. The building assembly has an opening within the hot work area as shown in Figures 4 and 5. Openings may allow hot work ignition sources to pass through, exposing combustible material on the opposite side of the assembly. Examples of openings include: penetrations for cables, piping, conveyors, or ventilation ductwork; stairways; or equipment or personnel doors. Refer to Section 2.5.2.2.1 when defining the hot work area on elevated mezzanines or open process structures.

B. The hot work site is on or near thermally-conductive materials passing through the building assembly. Thermal conduction may ignite combustible material on the opposite side of the assembly. Examples of thermally-conductive materials include metal piping or steel structural members.

2.5.2.2.8 Identify and safeguard any combustible-lined equipment, piping, and/or ducts in the hot work area when the equipment has openings that could allow hot work ignition sources to enter. Refer to Section 2.5.2.2.2 for recommendations on covering openings, or Section 2.5.2.3.6 for recommendations on protecting combustible-lined equipment.

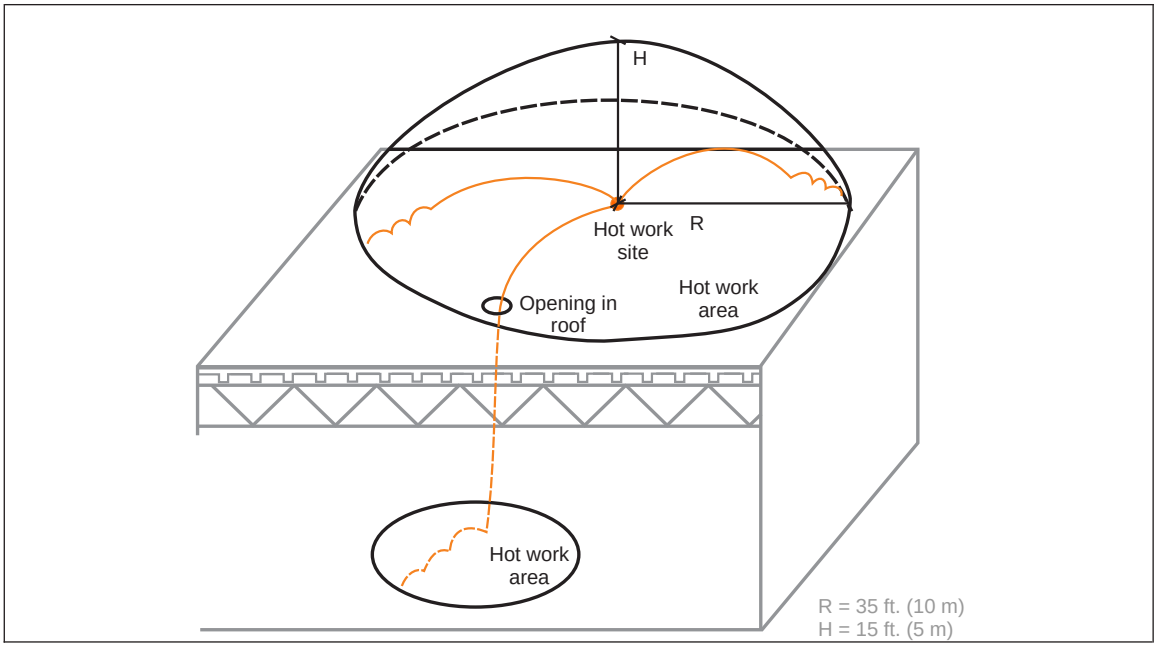


Fig. 4. Rooftop hot work permit-required area

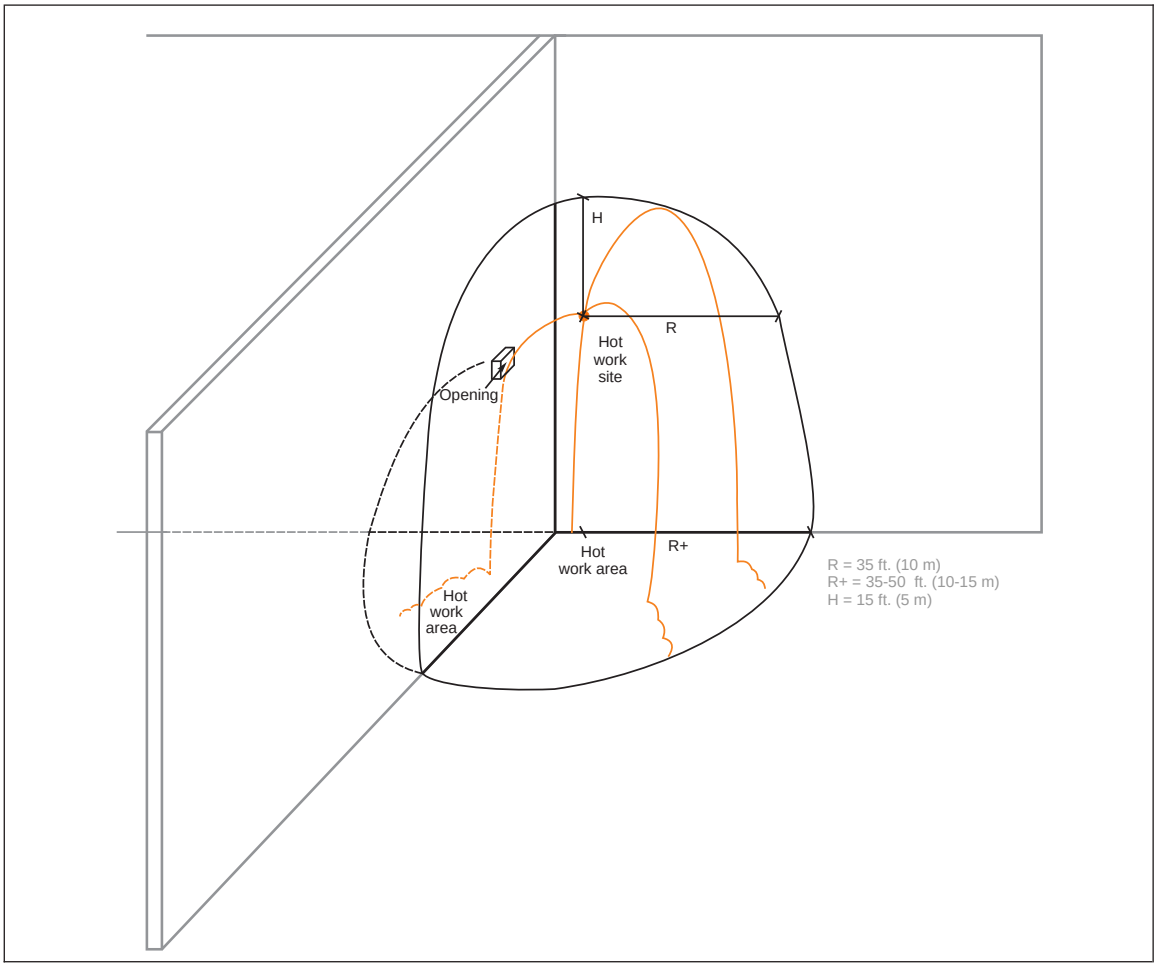


Fig. 5. Elevated hot work permit-required area

2.5.2.2.9 Treat hot work on thermally-conductive materials at or near penetrations into combustible building assemblies as a hot work high-risk operation. In addition, take the following additional required precautions:

A. Remove portions of the building assembly around the penetration and use suitable noncombustible replacements.

B. Monitor the temperature of the thermally-conductive material before the penetration.

C. Temporarily install a thermal sink on the thermally-conductive material before the penetration.

D. Perform fire watches using an infrared camera to inspect for hot spots. Stop work immediately and initiate emergency action if hot spots are detected.

E. Report all “hot spots” or fires, even if extinguished to the fire service. Smoldering may continue after extinguishment and may take place for hours before flaming begins in areas unsuspected by non-professionals.

2.5.2.2.10 Treat hot work on combustible building assemblies as a hot work high-risk operation. Examples of such hot work may include cutting through a non-FM Approved (Class 2) insulated steel deck roof or insulated metal panel, or welding seams of insulated metal panels. When performing these operations, follow the guidelines of the building system manufacturer, and take the following additional required precautions:

A. Develop a fire emergency response plan that includes conditions under which the fire service should be notified, and verify the fire service has access to the work area.

B. Stop work immediately if material appears to be smoking.

C. Perform fire watches using an infrared camera to inspect for hot spots. Stop work immediately and initiate emergency action if hot spots are detected.

D. Report all “hot spots” or fires, even if extinguished to the fire service. Smoldering may continue after extinguishment and may take place for hours before flaming begins in areas unsuspected by non-professionals.

2.5.2.2.11 Treat work on torch-applied roofing systems as a hot work high-risk operation. Work may include installing, altering, or repairing roof systems. Torch-applied roofing includes modified bitumen roof covers using an open-flame roofer’s torch. When using torch-applied roofing systems, follow the guidelines of the roofing system manufacturer, and take the following additional required precautions:

A. Follow guidelines within FM Global Data Sheet 1-33, *Safeguarding Torch-Applied Roof Installations*.

B. Develop a roof-fire emergency response plan that includes conditions under which the fire service should be notified, and verify the fire service has access to the work area.

C. Stop work immediately if roofing materials appear to be smoking.

D. Conduct a continuous fire watch over the hot work area during torch application.

E. Conduct the post work fire-watch in accordance with Note 1 of Table 1, and adhere to the following:

1. Where thermal imaging such as an infrared camera is used to check all roof areas worked on for hot spots, if temperatures are in excess of 250 °F (121 °C), remove and safely discard all charred or smoldering insulation and roof covering, including materials within a 4 ft (1.2 m) radius beyond. Initiate emergency action if hot spots are detected.

2. Inspect the entire top surface of the roof area worked on as well as the inside of the building for signs of fire, dripping bitumen or smoke. Pay particular attention to areas around roof expansion joints and other roof penetrations.

F. Conduct fire monitoring in accordance with Note 1 of Table 1 and 2.5.4.2.

G. Report all “hot spots” or fires, even if extinguished to the fire service. Smoldering may continue after extinguishment and may take place for hours before flaming begins in areas unsuspected by non-professionals.

H. When using an asphalt kettle: Locate the kettle a minimum of 25 ft (7.5 m) from the building and combustible yard storage, ensure the kettle is attended at all times while in operation, and provide an appropriate fire extinguisher nearby.

I. Close all valves supplying fuel-fired equipment when unattended.

2.5.2.3 Prepare for Hot Work on/in Equipment and Piping

2.5.2.3.1 Identify and isolate interconnected equipment and piping that contains flammable gas, ignitable liquid, or combustible dust/lint. Refer to Section 2.5.2.2.4 for recommendations on isolating interconnected equipment and piping.

2.5.2.3.2 Drain ignitable liquid and purge flammable gas/vapor from equipment and interconnected piping in accordance with Data Sheet 7-59, *Inerting and Purging.* When draining equipment, identify low-points in equipment and/or piping that may contain trapped liquid.

2.5.2.3.3 Test equipment and/or piping for flammable gas/vapor prior to work and as-needed during work. Consider conducting routine checks or continuous atmosphere monitoring during work if a less-reliable isolation method is employed as discussed in Section 2.5.2.2.4 or other high-risk factors are present in the work area.

2.5.2.3.4 When warranted by facility conditions, test for flammable gas/vapor or conducting atmosphere monitoring in enclosed equipment, piping, and/or ductwork, even if the equipment does not normally contain flammable gas or ignitable liquid. Flammable materials can contaminate nonflammable process streams, or flammable decomposition products can be produced by decaying organic materials. For example, contamination can occur in waste-water collection and treatment equipment due to upset operating conditions or loss of mechanical integrity of a heat exchanger.

2.5.2.3.5 Remove combustible debris, dust/lint, and residue from equipment and interconnected piping. Inspect equipment and piping internals for combustible materials. Perform the appropriate housekeeping activities to clean the equipment prior to work.

2.5.2.3.6 Treat hot work on combustible-lined equipment, piping, or ductwork as a hot work high-risk operation. In addition, take the following additional required precautions when warranted by facility conditions:

A. Use an alternative cold work method.

B. Label combustible-lined equipment, piping, and/or ductwork with easily recognizable warning signs. Locate warning signs in high-traffic or readily visible areas (e.g., above personnel access hatches or near travel paths and walkways).

C. Flood equipment, piping, and/or ductwork with water. Alternatively, continuously wet-down combustible surfaces with water spray during work and during the post-work fire watch period.

D. Identify access ports upstream and downstream of the hot work site and lay out hose lines at those access ports.

E. Isolate equipment, piping, and/or ductwork upstream and downstream of the hot work site using an appropriate isolation method such as blanking and physically breaking equipment. Note that blanking alone may not provide a sufficient fire-break because thermal conduction through the blank can ignite combustibles on the opposite side.

2.5.3 Required Precautions During Hot Work

2.5.3.1 During hot work, perform a continuous fire watch over the hot work area. Include the following responsibilities in the fire watch:

A. Continuously supervise the hot work area and the person performing the work to ensure fire-safe conditions are maintained. A fire watch must be maintained within the hot work area continuously from the start of work to completion of work, even during breaks. If the fire watch needs to leave the hot work area, assign a temporary or permanent replacement in order to maintain a continuous watch.

B. Ensure hot work ignition sources are confined within the defined hot work area. The fire watch is responsible for stopping hot work if unsafe conditions are identified.

C. Maintain the required precautions in place.

D. In the event of a fire, notify emergency contacts prior to attempting to extinguish the blaze, regardless of size.

2.5.3.2 Provide a second fire watch when **any** of the following conditions exist:

A. The hot work area and person performing the hot work are not visible from a single vantage point.

B. The hot work area is large, multi-level, and/or congested.

C. The hot work area extends to the other side of a building assembly due to an opening or thermally-conductive penetration.

2.5.3.3 Restrict the scope of a hot work permit to that defined on the authorized permit. Ensure the type of hot work operations and the location of hot work sites do not change once the permit is authorized. Changes may require redefining the hot work area and modifying the required precautions. If conditions do change, stop work and reauthorize the permit before continuing.

2.5.4 Required Precautions After Hot Work

2.5.4.1 After hot work has concluded, perform a continuous fire watch over the entire hot work area (including areas requiring a second fire watch per Section 2.5.3.2). Refer to Section 2.5.3.1 for the responsibilities of the post-work fire watch, and refer to Section 2.5.4.3 for the recommended fire watch period.

2.5.4.2 After the post-work fire watch has concluded, perform fire monitoring within the hot work area. Use one of the fire monitoring methods listed below and refer to Section 2.5.4.3 for the recommended fire monitoring period:

A. Automatic smoke detection system with remote alarm that sounds in a constantly-attended location.

B. Security video cameras with clear coverage of the hot work area. Locate camera displays in a constantly-attended location. Cameras with infrared capability are preferred.

C. Operators routinely present in the hot work area. Train operators to monitor for fire-safe conditions, maintain required precautions in place, and notify emergency contacts before making any attempt to extinguish the fire.

D. Personnel to intermittently patrol the hot work area for fire-safe conditions. At a minimum, patrol the hot work area at least every 15 minutes. Train personnel to monitor for fire-safe conditions, maintain required precautions in place, and notify emergency contacts prior to attempting to extinguish a fire, regardless of size.

2.5.4.3 Provide post-work fire watch and fire monitoring periods as follows:

A. Provide a 1 hr post-work fire watch and a 3 hr fire monitoring period.

B. If combustible construction with unprotected concealed cavities are present or torch applied roofing is being conducted, use Table 1 to determine post-work fire watch and monitoring periods.

C. If favorable factors are present, use Table 1 to determine reduced post-work fire watch and monitoring periods. Clients of FM Global should not modify post-work fire watch and monitoring periods from Table 1 without first discussing the modifications with their FM Global field engineer or client service team.

2.5.4.4 When conducting hot work in unprotected areas (e.g., unsprinklered), fire monitoring becomes more critical as a primary means of protecting against hot work fires. Treat unprotected areas as hot work high-risk areas and refer to Section 2.5.2.1.3 for additional required precautions.

Table 1. Construction and Occupancy Factors for Determining Post-Work Fire Watch and Fire Monitoring Periods [1, 2]

Occupancy Factors	Construction Factors						
		Noncombustible construction or FM Approved Class 1 or Class A building materials		Combustible construction without concealed cavities [3]		Combustible construction with unprotected concealed cavities [4]	
		Watch	Monitor	Watch	Monitor	Watch	Monitor
	Noncombustible with any combustibles contained within closed equipment (e.g., ignitable liquid within piping)	30 min.	0 hours	1 hour	3 hours	1 hour	5 hours
	Office, retail, or manufacturing with limited combustible loading (e.g., HC-1 or HC-2)[5]	1 hour	1 hour	1 hour	3 hours	1 hour	5 hours
	Manufacturing with moderate to significant combustible loading (e.g., HC-3) except as noted below [5]	1 hour	2 hours	1 hour	3 hours	1 hour	5 hours
	Warehousing	1 hour	2 hours	1 hour	3 hours	1 hour	5 hours
	Exceptions: Occupancies with processing or bulk storage of combustible materials capable of supporting slow-growing fires (e.g., paper, pulp, textile fibers, wood, bark, grain, coal or charcoal)	1 hour	3 hours	1 hour	3 hours	1 hour	5 hours

[1] When performing torch applied roofing, apply Section 2.5.2.2.11 and conduct a minimum 2 hours fire watch and 2 hours fire monitoring. If an infrared camera is utilized, reduce to a 1 hour fire watch and 1 hour fire monitoring.

[2] When performing hot work on/in equipment containing non-removable combustible linings or parts, apply Section 2.5.2.3.6 and conduct a minimum 1 hour fire watch and 3 hours fire monitoring within the equipment, and in the surrounding areas per Table 1.

[3] This construction-type does not contain small combustible wall or ceiling cavities where smoldering fires can grow undetected. For example, open wood frame walls (sheathed on one side), exposed wood joists, beams, or trusses, or non-FM Approved insulated metal panels.

[4] This construction-type allows for smoldering fires to grow undetected within small combustible wall or ceiling cavities. Typically these cavities are sufficiently small to not warrant sprinkler protection or subdivision via fire barriers. For example, enclosed wood frame wall (sheathed on two sides), EIFS, or channels created between combustible floor and joist with ceiling construction tightly fastened underneath.

[5] HC-1, HC-2 and HC-3 refer to a group of occupancies listed within Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties*.

2.6 Low-Energy Hot Work

2.6.1 Define an appropriate hot work area around low-energy ignition sources. Clear separation less than 35 ft (10 m) may be acceptable.

2.6.2 Remove nonessential combustible materials from the low-energy hot work area. When combustibles are needed to support routine production (e.g., staged work-in-process or assembly parts), enclose the combustibles in metal cabinets, or isolate combustibles from hot work ignition sources using FM Approved hot work welding blankets or curtains.

2.6.3 Restrict the use of ignition-sensitive materials such as ignitable liquid, flammable gas/vapor, or light-weight fibrous materials in the low-energy hot work area. When ignition-sensitive materials are needed to support routine production, store ignitable liquids in FM Approved storage cabinets for flammable and combustible liquids. When low-energy hot work is conducted in hot work permit-required areas containing ignition-sensitive materials, use a hot work permit.

2.6.4 When low-energy hot work equipment is used in support of routine production, safeguard the equipment to prevent continued operation while unattended (e.g., electric soldering irons). Use either of the following options to ensure hot work equipment is shutdown while unattended:

A. Install a deadman-style switch to disconnect electrical power to equipment when operators are not present.

B. Install timing relays to disconnect electrical power to equipment when the areas are not normally attended (i.e., outside of normal work hours).

2.6.5 After the low-energy hot work has concluded, perform fire monitoring within the hot work area for at least 30 minutes. Refer to Section 2.5.4.2 for guidance on fire monitoring.

2.6.6 Provide fire extinguishers within the low-energy hot work area per local codes. Inspect, test, and maintain fire extinguishers per Data Sheet 2-81, *Fire Protection System Inspection, Testing, and Maintenance.*

2.6.7 Conduct inspections of low-energy hot work areas to ensure required precautions are maintained. Inspect work areas at least weekly.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Supplemental Information

3.1.1 Hot Work Operations

3.1.1.1 High-Energy Hot Work Operations

Examples of high-energy hot work operations include the following:

A. Field (Infrequent)

1. Metal-working that involves radial-mechanical or torch cutting, grinding, welding, and heat treating
2. Pipe assembly and installation, including radial saw cutting, wheel grinding, and soldering, brazing, and welding joints
3. Installation of powder-driven fasteners
4. Thawing ice plugs in piping (in place)
5. Torch-applied roofing

B. Production (Routine)

1. Metal-working that involves radial-mechanical or torch cutting, grinding, and welding or hot riveting
2. Pipe fabrication producing ERW or helical pipe
3. Thermal spraying
4. Shrink wrapping using fuel-fired burners (e.g., hand-held weed burners)

Figure 6 compares common hot work ignition source temperatures to the ignition temperatures of several solid materials.

3.1.1.2 Low-Energy Hot Work Operations

Examples of low-energy hot work operations include the following:

A. Field (Infrequent)

1. Heat welding single-ply membrane joint using an electric welding iron.
2. Soldering repair or alteration within installed electrical/electronic equipment
3. Unrated electrical equipment temporarily used in hazardous/classified electrical area.
4. Cold-work drilling, cutting in hazardous/classified electrical area.

B. Production (Routine)

1. Soldering an electrical/electronic component
2. Fusing plastic pipe or other part
3. Hot gluing
4. Shrink-wrapping using electrically-heated hot air gun

3.1.2 Hot Work Management Programs

At most facilities, human element programs require basic administrative controls for effective implementation and long-term viability and reliability. The hot work management program is no exception. Most programs require ownership, a policy statement and procedures, training, document retention, and auditing.

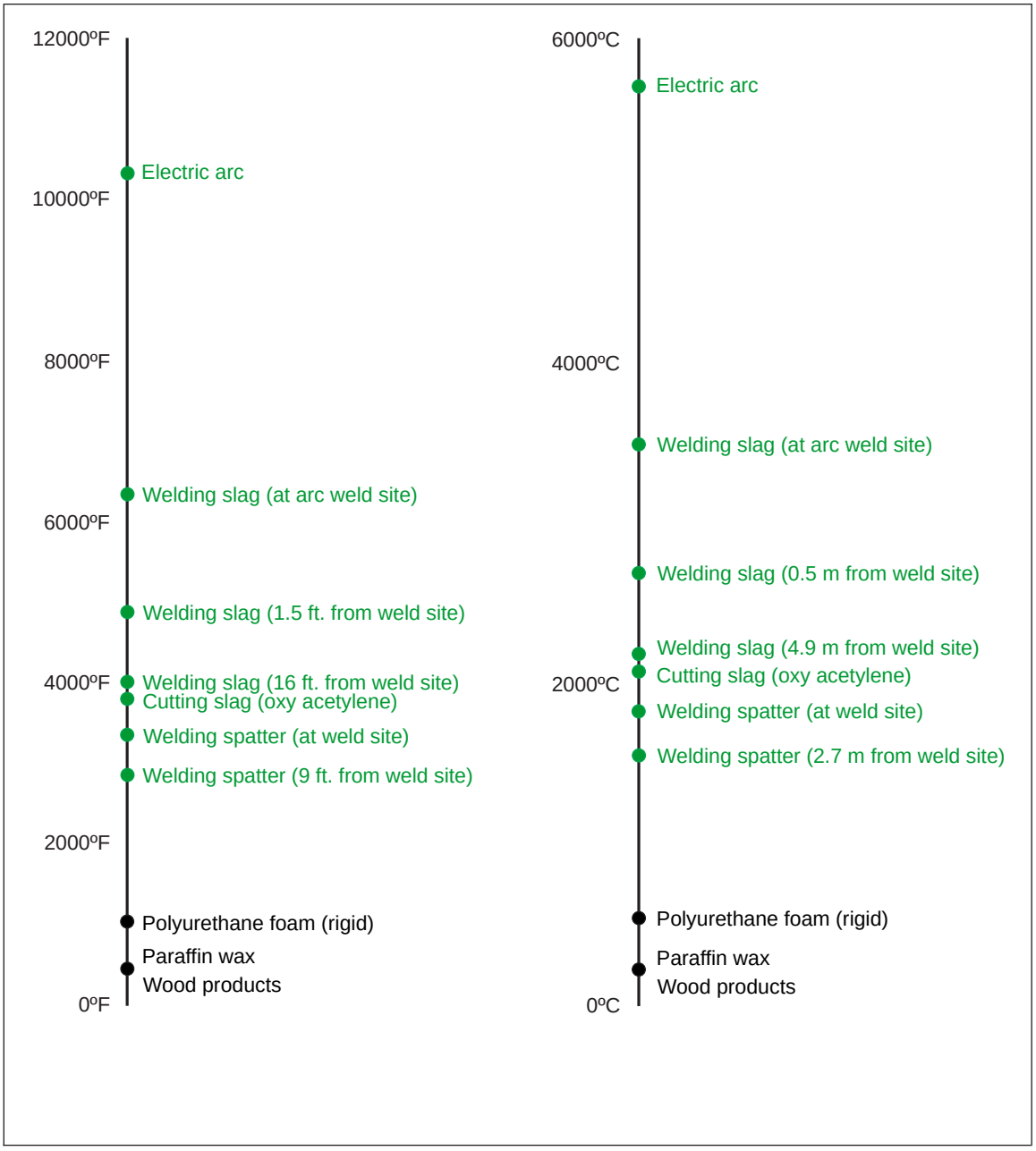


Fig. 6. Hot work ignition source temperature vs. solid-fuel ignition temperature

A policy statement should set the ground rules for conducting hot work both inside and outside buildings. Alternative cold work methods and relocating the work to a hot work designated area should always be considered first. If hot work is unavoidable, the policy should define the location of hot work designated areas and hot work production areas. One of the most important aspects of the policy is to define the rules for hot work permit-required areas (including procedures to be used) and identify hot work high-risk areas.

Procedures and training should supplement the policy statement with more details on inspection of hot work designated areas and hot work production areas, and rules for permit-required hot work including preparing the hot work area, permit authorization, and permit expiration. Preparing the hot work area and/or equipment is arguably the most critical aspect of performing hot work that requires a permit. All hot work fires and explosion can be prevented by controlling combustible, ignitable, and flammable materials. A hot work fire or explosion will not occur unless hot work ignition sources come into contact with these materials. However,

in practice, controlling fuel and ignition sources can be difficult, and methods of doing so can, at times, be unreliable. As a result, a second layer of protection should be provided during permit-required hot work to mitigate the consequences of a hot work fire. Examples include ensuring fire protection systems are in service, and supervising the hot work area during and after the work to check for fire-safe conditions.

3.1.3 Alternative Cold Work Methods

Alternative cold work methods should be explored whenever hot work is considered. Cold work is an inherently safer method from a fire or explosion risk standpoint because the operation does not create an ignition source. Examples of cold work methods are provided in Table 2.

Table 2. Alternative Cold Work Methods

Hot Work Operation	*Alternative Cold Work Method*
Thawing ice plugs in piping (in place) using an open-flame	Mechanical removal and relocation of frozen piping to a heated area
Torch cutting	Hydraulic shear cutting (metal-working)
Radial saw cutting (metal-working)	Reciprocating saw cutting (metal-working)
Welding (metal-working)	Mechanical bolting
Soldering metal pipe joints	Threaded, flanged, coupling, or mechanical pipe joints
Torch-applying roof cover systems	Mechanically fastened or fully-adhered roof cover system
Puddle welding steel roof decking to structural members	Mechanically fastened steel roof deck to structural members

3.1.4 Hot Work Designated or Production Areas

Combustible and flammable material should be restricted from entering areas in which hot work ignition sources are prevalent. This includes construction used to enclose hot work designated areas or hot work production areas. At a minimum, a continuous barrier should be provided to confine hot work ignition sources and prevent them from coming in contact with combustible constructions or occupancies.

3.1.5 Hot Work That Requires a Permit

Hot work that requires a permit should be used as a last resort when alternative cold work methods or relocating the work to a hot work designated area are not feasible. When considering hot work that requires a permit, a safety review should be conducted and a plan developed to conduct the work safely. A hot work permit should be used to document the hot work management plan and precautions to be taken in the hot work area.

Prior to the work, the permit authorizer is responsible for verifying the precautions are implemented and authorizing the hot work permit, while the fire watch assumes the responsibility of ensuring the precautions remain in place during and after the work. The permit should be posted in the hot work area as a warning, as a reference of the required precautions, and for documenting during-work and post-work precautions such as periodic atmosphere monitoring and post-work sign-offs.

Conceptually, hot work permit precautions are intended to accomplish the following prior to work, during work, and/or post-work:

A. Identify and remove combustible, ignitable, or flammable materials from the hot work area prior to work.

B. Verify fire protection systems are in-service prior to work.

C. Restrict combustible or flammable materials from entering the hot work area during-work or post-work (e.g., combustible creep as materials, tools, and/or packaging enter the active work area).

D. Verify hot work ignition sources remain within the defined hot work area during-work.

E. Supervise the hot work area for fire-safe conditions (during-work and post-work).

3.1.6 Hot Work High-Risk Areas

Hot work high-risk areas pose an increased level of risk in comparison with other areas of the facility. Additional required precautions may be necessary when conducting hot work in these high-risk areas due to the increased likelihood or severity of a fire or explosion. The intent is not to prohibit hot work in these areas, but to bring more awareness and additional precautions to safely conduct hot work that requires a permit.

The pre-work safety review in these high-risk areas should strongly consider alternative cold work methods or relocating the work to a hot work designated area. If hot work is unavoidable, additional required precautions may be warranted, including charged firefighting hose lines with trained firefighting personnel; fire service notification; isolating, draining, and purging equipment with continuous atmosphere monitoring; permit authorization by local senior management; and/or watch and monitoring using an infrared camera.

3.2 Loss History

3.2.1 Illustrative Losses

The following loss summaries highlight the importance of good hot work management practices.

3.2.1.1 Inadequate Preparation of the Hot Work Area

3.2.1.1.1 Fire at a Corrugator Due to Inadequate Removal of Combustible Dust Accumulations

The facility manufactured corrugated boxes. The building housing the corrugator consisted of noncombustible construction with steel joists supporting the roof deck. Ceiling-level automatic sprinkler protection was provided.

During a maintenance shutdown, repairs were being made to a corrugator roll stand. In preparation for the work, a hot work permit was completed, with precautions checked off and the permit authorized by a supervisor. After torch cutting the work piece, grinding was completed. Initially the grinding operation directed the sparks toward the ground, but upon rotating the grinder around the work piece, the sparks were spraying against the underside of the lower-height ceiling. Within minutes, a fire flashed across the ceiling, opening more than 50 sprinklers. The fire was eventually controlled by automatic sprinklers and the fire service.

The hot work management program failed to recognize combustible dust deposits in the hot work area. Paper dust was present on joists and along the underside of the ceiling above the corrugator. Fortunately, sprinklers were installed and in service to limit fire spread.

3.2.1.1.2 Fire at a Sawmill Debarker due to Inadequate Safeguarding of Combustible Construction and Buildup of Combustible Dust

The facility was a softwood dimensional lumber mill. The debarker was situated next to the building housing a head-rig saw. The building was constructed of mostly combustible construction. Automatic sprinkler protection was provided through the facility, including the log deck and sawmill building.

During a weekend mill shutdown (Friday evening through Monday morning), repairs were made in the debarker area. In preparation for the work, employees and contractors completed multiple hot work permits for the cutting, grinding, and welding. Following the final hot work operation on Sunday, the hot work area was reportedly fire-safe for 5.5 hours.

Approximately 6.5 hours after the final hot work operation, a fire erupted within the sawmill building, activating sprinklers and triggering an emergency response. Sprinklers and manual firefighting efforts proved ineffective. Before sprinklers activated, the fire had spread into combustible concealed spaces within the exterior wall adjacent to the debarker, and into the ceiling. The fire spread through the sawmill building until it was eventually controlled 15 hours later. The fire service prevented fire spread into adjacent buildings.

Hot work permits were completed. Rather than removing or covering combustibles (bark, chips, saw dust, and combustible construction), hot work areas were wet-down. A 1-hour fire watch and 3-hour fire monitoring were provided. Sprinklers were in service, but ineffective against a fire in a combustible concealed space.

3.2.1.1.3 Fire at an Aluminum Smelter in a Cast House Involving Cabling and Combustible Dust

The facility was an aluminum smelting and casting facility. The cast house consisted of noncombustible construction. No automatic sprinkler protection was provided.

During a night shift, contractors were installing a new gas supply line to a furnace. The gas piping was assembled using welded joints and run at ceiling-level. While working, the welder noticed a small fire involving dust accumulations below the hot work site on a steel beam flange. The welder attempted to extinguish the fire using his foot, then a fire extinguisher. The fire extinguisher dispersed the dust and fire spread to a cable tray below that also contained dust deposits. The fire spread on the horizontal cable tray, then vertically to a main cable rack containing cables feeding the entire cast house. The fire was extinguished by facility personnel after isolating power and using fire extinguishers.

The cast house was not a hot work permit-required area. Instead of a hot work permit, a work permit was used that identified a fire risk requiring a fire watch. Regardless of the permit used, the facility failed to properly remove or protect combustibles in the hot work area.

3.2.1.1.4 Fire at a Metal-Working Facility Involving a Belt Conveyor and Combustible Residue

A facility manufactured rotors and stators for electric motors. The production building was steel-frame construction with steel purlins supporting insulated metal panels. Walls were cinderblock. The cast house consisted of noncombustible construction. Automatic sprinkler protection was provided in the fire area.

During a night shift, employees were torch-cutting in the vicinity of a press at floor level. Sparks fell into a conveyor pit beneath the row of 10 mechanical presses, igniting oil residue and the wide rubber conveyor used to collect scrap metal from the presses. Sprinkler protection in the conveyor pit was impaired and the fire spread throughout the tunnel, damaging all presses. The fire was eventually extinguished after consuming most of the available fuel.

A hot work permit was not used. Workers failed to recognize the combustible materials in the pit underneath the hot work site or verify that fire protection was in service.

3.2.1.1.5 Fire at a Food-Processing Facility Involving Combustible Wall Construction

A meat processing and packing plant had interior insulated metal panel walls. Automatic sprinkler protection was provided throughout the building of fire origin.

A contractor was cutting and welding a metal sleeve penetration through a thick insulated metal panel wall assembly (multiple wall panels plus additional insulation) in preparation for installing an exhaust duct. The work ignited the insulation and the fire spread upward and through the insulated wall cavity.

A hot work permit was not used. Workers failed to recognize the combustible wall construction.

3.2.1.1.6 Fire at a Sawmill Involving Combustible Debris with Impaired Fire Protection

A sawmill produced kiln-dried dimensional lumber. It had a mostly combustible roof and combustible cavity walls. Automatic sprinkler protection was provided throughout the building of fire origin.

During a weekend maintenance shutdown, a contractor was cutting on production equipment. In preparation for the work, a hot work permit was completed and authorized and the hot work area was wet down with a process water line on both the production floor and open areas below. Shortly after beginning work, the fire watch discovered a smoldering fire beneath the hot work site. When attacked with the wet-down hose, the fire flared and begin spreading. Mill personnel responded with wet-down houses and fire hoses, and notified the fire service. Several minutes into the fire, a closed sprinkler control valve was opened. Over the next few hours, a combination of sprinklers and firefighting efforts controlled the fire. Eighteen hours after the fire began it was officially extinguished. The building suffered significant damage due to the smoldering fires in combustible concealed spaces, and the fire service having opened building wall, ceiling, and roof cavities.

A hot work permit was used; however, the permit authorizer was unaware sprinkler protection in the hot work area was impaired because impairment management procedures were not followed. Combustible accumulations and residue were not removed (wet down) and non-moveable combustible materials (combustible construction and cables) were not covered.

3.2.1.1.7 Fire at a Steel Pickling Plant in a Boiler Room Involving Combustible Wall Construction

The facility pickled, slit, and stamped hot rolled steel coils. The plant was mostly noncombustible construction with steel frame supporting standing seam metal panels. The interior steel surfaces were coated, shielded with fiberglass reinforced plastic panels, or insulated with expanded foam to limit acid corrosion. Automatic sprinklers were not provided within the building.

Employees were cutting steel equipment supports in the boiler room when exposed foam insulation was ignited. The workers left the room to alert building personnel. The fire quickly spread along combustible wall and ceiling surfaces. Several hours after ignition, having consumed most of the available combustible loading in the area, the fire was extinguished by the fire service.

A hot work permit was used, but information was not available on most of the precautions implemented. A during-work fire watch was not in place. The workers failed to recognize the exposed foam insulation.

3.2.1.1.8 Fire at a Sawmill Involving Combustible Debris with Impaired Fire Protection

The facility was a sawmill that produced dimensional kiln-dried lumber. The subject mill building consisted of either steel or wood frame supporting a combustible roof, while walls were mostly wood on wood frame. Automatic sprinkler protection was provided throughout.

Employees were torch-cutting sprinkler piping on the sawmill operating floor. The workers broke for lunch. Later on, other personnel returning from work noticed a glow on the floor below the operating floor. Personnel attacked the fire with a fire hose and later the sprinkler control valve was opened (system was under repair). Five hours later the fire was extinguished by the fire service after controlling spread and limiting the fire to the building of origin.

A hot work permit was used, but information was not available on most of the precautions implemented. The workers failed to recognize floor openings and remove combustible accumulations from the floor below. A continuous during-work fire watch was not in place during the lunch break. Sprinkler protection was impaired during the work.

3.2.1.2 Inadequate Preparation for Hot Work on or in Equipment

3.2.1.2.1 Fire at a Power-Generating Facility Involving Combustibles Within Equipment

The facility was a gas-fired combined cycle power generating station. The power generating and ancillary equipment was contained within an open steel process structure while support buildings were of noncombustible construction.

During a maintenance shutdown, repairs were being made to close holes that had opened in the air inlet filter housing serving a gas turbine. In preparation for the work, a hot work permit was completed because the holes were to be welded closed. The hot work ignited the filters and the evaporative cooler within the unit. The fire was controlled several hours later using hose streams.

Details on the completed hot work permit were not available. Regardless, the permit authorizer and/or workers failed to recognize the combustible filters and other components within the unit that could be in contact with thermally-conductive work surfaces, or exposed to molten slag or sparks via the functional openings in the inlet filter housing.

3.2.1.2.2 Fire at a Power-Generating Facility Involving Combustibles Within Equipment

The facility was a coal-fired power generating station. The coal bunkers were located in a room constructed of noncombustible or fire-resistive construction with fiberglass insulated metal panels. The dust collector served a dozen coal bunkers used to stage coal in the building.

During a shutdown of the dust collection system, a contractor was altering the inlet ductwork to the collector. In preparation for the work, a contractor hot work checklist analysis was used, rather than a hot work permit, for the cutting and grinding to be completed. Several hours after restarting the dust collection system, smoke was detected emanating from the collector and the collector was hot. The fire service extinguished the fire within an hour. The preaction sprinkler system installed within the collector did not automatically trip, nor was the deluge valve manually operable.

Details on the completed hot work checklist analysis were not available. Regardless, the workers failed to recognize the combustible filters or combustible dust deposits in the system, and sprinkler protection was impaired.

3.2.1.2.3 Fire at a Mining Complex Involving Combustible-Lined Equipment

The facility was a gold-silver mining and ore processing complex. The dust collection system (cyclones) serving two ball mills was located in a mostly noncombustible building consisting of Class 1 insulated steel deck roof on purlins and steel trusses, and Class 1 insulated metal panel walls. No automatic sprinkler protection was installed.

During a process slow-down, an employee was weld-repairing a crack in a roughly 3 ft (1 m) diameter rubber-lined pipe discharging from the ball mill cyclones. In preparation for the work, the facility completed a hot work permit for the weld repair. While welding on the pipe, the worker noticed the pipe was hotter than usual, as compared to previous weld repairs, and concluded the 2.5 in. (6.4 cm) thick rubber-lining was on fire. The helper rushed to insert a firefighting hose line upstream of the hot work site, but could not spray water into the piping due to insufficient access. After discharging fire extinguishers into the upstream end of the burning piping, the welder and helper were forced to evacuate. A smoke detection alarm notified the emergency response team and the fire service. The milling operator attempted to inject slurry and water into the burning piping; however, the fire had already compromised control valves and wiring. The fire service spent five hours battling the fire within the rubber-lined equipment and a small roof fire involving a combustible parapet.

Details on the completed hot work permit were not available. Regardless, the workers failed to take the appropriate required precautions when working on combustible-lined piping. The piping was mechanically coupled, so the damaged pipe segment could have been removed and relocated to a hot work designated area during a production outage. If the work needed to be conducted in the field, additional required precautions should have been considered, such as flooding or continually spraying water into equipment, staging a firefighting hose line upstream and/or downstream of the hot work site, or disconnecting piping upstream and/or downstream of the hot work site.

3.2.1.2.4 Explosion of a Pulp Mill Digester Blow-Tank Involving Flammable Gas Within Equipment

The facility was a pulp mill consisting of two parallel pulp production streams. The blow tank was a vertical, four-story tank receiving cooked chips from batch digesters. A roof-mounted cyclone supported blow-tank operations by separating fiber from the volatile organic compounds (VOC) produced as a by-product of chemical pulping. The blow-tank had several inlet and discharge connections in the lower tank hopper.

During a planned shutdown, repairs were done on and around the blow-tank at several locations. In preparation for the work, the tank was emptied, purged of VOCs, and locked out. Atmosphere monitoring was done around the open manway and inside the upper portion of the tank. At some point during the work, a water hose was inserted to the blow-tank through an upper manway, which was immediately followed by an explosion that ruptured the blow-tank dome, tore apart the duct leading to the cyclone, and relieved from the building through the roof.

Details on the completed hot work permit were not available. Regardless, the facility failed to properly isolate the tank from sources of VOCs and detect the heavier-than-air VOCs collecting in the tank hopper several stories below the manway used for atmosphere monitoring. The lock-out procedure called for opening the bottom tank connections, which may have been the source of VOCs as determined after the incident. The water spray likely stirred the VOCs mixing with air and were either exposed to a hot work ignition source while in the tank (entered the tank through an open manway), or VOCs were ejected through an open manway where the flammable atmosphere was exposed to active hot work sites in the immediate vicinity around the tank and the flame front propagated/flashed back into the tank (grinding and welding).

3.2.1.2.5 Explosion at a Pharmaceutical Plant in a Waste-Water Recovery Tank Involving Flammable Gas Within Equipment

The facility was pharmaceutical plant producing active pharmaceutical ingredients. A roughly 10,000 gal (270 m^3) tank was used to collect waste water for treatment prior to being released.

Alterations were done on the inlet line to the tank. In preparation for the work, a hot work permit was completed. At some point during the work, an explosion occurred, relieving through the tank dome and wall seam.

Details on the completed hot work permit were not available. Regardless, the mill failed to either properly purge and detect, or isolate sources of VOCs from the tank and connected piping.

3.2.1.2.6 Fire at a Grain Elevator Leg Involving Combustible-Lined Equipment

The facility was a grain elevator with six bucket elevators. Building construction was reinforced concrete, while most grain-handling equipment was lined with either steel wear plates, ceramic tile, or plastic. No automatic sprinkler protection was provided.

While operating, repairs were made to an elevator down-spout that had a worn-through plastic liner and metal casing. Approximately 30 to 60 minutes after the work had been completed fires were detected in all elevators and interconnected plastic-lined equipment and belt conveyors. The fire service responded and was able to control the fires within one hour.

No hot work permit was used. The facility failed to recognize that plastic-lined equipment is a hot work prohibited area.

3.2.1.2.7 Fire at a Power-Generating Facility Involving Combustible-Lined Equipment

The facility was a coal-fired power generating station. The facility used absorbers that were used to scrub sulfur containing combustion products in the flue gas. The absorbers were tall concrete structures with plastic slurry distribution trays and other plastic components.

During a maintenance shutdown, repairs were made to cracks in the stainless steel ductwork leaving the absorber. The hot work site was located above and in close proximity to the plastic mist eliminators and distribution trays. After the work was completed, personnel noticed smoke emanating from the absorber exhaust stack. The emergency response team was unsuccessful at putting water into the absorber, so slurry pumps were turned on to circulate aqueous solution through the unit. The fire was eventually controlled about 90 minutes after detection.

No hot work permit was used. The facility failed to recognize there were combustible parts within the mostly noncombustible equipment. This was the second absorber fire in about 10 years caused by hot work at this facility.

3.2.1.2.8 Fire at a Mining and Ore Processing Facility Involving Combustible-Lined Equipment

The facility was a diamond mine and processing facility. The front-end of the processing facility utilized combustible equipment and rubber-lined equipment.

During a maintenance shutdown, employees were torch-cutting and performing cold-work on rubber-lined equipment. When workers broke for lunch a fire started and spread through equipment. It was eventually extinguished an hour later by the fire service.

A hot work permit was used. The facility failed to recognize combustible-lined equipment, and a continuous during-work fire watch was not employed.

4.0 REFERENCES

4.1 FM Global

Data Sheet 2-81, *Fire Protection System Inspection, Testing, and Maintenance*
Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Speinklered Properties*
Data Sheet 7-59, *Inerting and Purging of Tanks, Process Vessels and Equipment*
Data Sheet 7-78, *Industrial Exhaust Systems*
Data Sheet 10-4, *Contractor Managementmed*
Hot Work Permit System Kit with permit holster and permits (P9311k)
Hot Work Permit (F2630)
Don't Get Burned By Hot Work (P9802)
Pocket Guide to Hot Work Loss Prevention (P9602)
Understanding the Hazard: Hot Work (P0032)
Understanding the Hazard: Contractor Management (P0110)
Managing Hot Work Online Training Flyer (P0686a)
Advancing Hot Work Skills Online Training Flyer (P12062)
Managing Hot Work Online Training Flyer (P08109e)

4.2 Other

Australian Standard (AS) Safety in Welding and Allied Processes, Part 1: Fire Precautions. AS 1674.1.

Fire Protection Association (FPA). Recommendations for Hot Work. RC-7.

National Fire Protection Association (NFPA), *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*. NFPA 51B.

VdS Schadenverhuetung GmbH. Fire Protection Guidelines, ″Safety Guidelines for Hot Work″ Number VdS 2008:2009-07

APPENDIX A GLOSSARY OF TERMS

FM Approved: Products and services that have satisfied the criteria for Approval by FM Approvals. Refer to the *Approval Guide* for a complete list of products and services that are FM Approved.

Hot work: Any temporary or routine work (operation) involving open-flame, producing hot surfaces, and/or generating sparks or molten material of sufficient energy to ignite combustible, ignitable, and/or flammable materials. Examples of hot work operations include torch-applied roofing, pipe brazing, pipe soldering, arc and torch welding, radial-mechanical and torch cutting, grinding, and post-weld heating using a gas-fired burner or electrical resistance heater. For ignition-sensitive materials such as low-flash point ignitable liquids, flammable gas/vapor, and some combustible dusts, hot work may be expanded to include low-energy hot work ignition sources.

Hot work area: The space surrounding a hot work site defined by the horizontal or vertical reach of hot work ignition sources. Within this area combustible, ignitable, and flammable materials are temporarily removed or isolated.

Hot work designated area: An area of a facility in which hot work can be conducted without a hot work permit if combustible, ignitable, or flammable materials remain controlled or safeguarded.

Hot work production area: An area of a facility in which routine production-related hot work can be conducted without a hot work permit if the area meets the requirements of a hot work designated area.

Hot work permit-required area: An area in a facility in which hot work can be conducted only with a hot work permit and in a fire-safe manner (i.e., with required precautions in place). Typically, these areas are the portions of a facility that are outside hot work designated areas.

Hot work high-risk area or operation: An area of a facility in which hot work can be conducted with a hot work permit but additional required precautions may be necessary given the increased level of fire or explosion risk.

Hot work site: The location of the work activity where hot work ignition sources originate.

Low-energy hot work: Any temporary or routine work (operation) capable of producing mechanical sparks, electrical or electrostatic sparks, or hot surfaces of sufficient energy to ignite ignition-sensitive materials commonly found in hazardous/classified electrical areas (e.g., low-flash point ignitable liquids, flammable gas/vapor, and some combustible dusts); or ordinary combustibles due to prolonged contact with hot surfaces. Examples of low-energy hot work operations include drilling, chiseling, mechanical abrasion (sandblasting), use of unrated equipment in hazardous/classified areas (e.g., mobile phones, laptop computers, tablets, portable instrumentation, or vehicles), electrically heated hot irons or hot-air blowers, and ungrounded personnel or equipment.

Welding blanket, FM Approved: A heat-resistant fabric designed to be placed in the vicinity of a hot work operation. The blanket is intended for horizontal orientation while subjected to light to moderate thermal exposures from hot work activities such as grinding, mechanical cutting, heat treating, and welding that does not result in molten metal contact (i.e., no slag exposure). The blanket is capable of resisting burn-through and thermal conduction through the blanket that may ignite combustibles on the opposite side of the blanket. A blanket provides less thermal protection than a pad, but more than a curtain.

Welding curtain, FM Approved: A heat-resistant fabric designed to be placed in the vicinity of a hot work operation. The curtain is intended for vertical orientation while subjected to light to moderate thermal exposures from hot work activities such as grinding, mechanical cutting, and welding that does not result in molten metal contact (i.e., no slag exposure). The curtain is intended to prevent sparks from escaping a confined hot work area. A curtain provides the least thermal protection compared to a blanket or pad.

Welding pad, FM Approved: A heat-resistant fabric designed to be placed directly beneath a hot work operation. The pad is intended for horizontal orientation while subjected to moderate to severe thermal exposures from hot work activities such as torch cutting and welding that may result in molten metal contact (i.e., slag exposure). The pad is capable of resisting burn-through and thermal conduction through the pad that may ignite combustibles on the opposite side of the pad. A pad provides the most thermal protection compared to a blanket or curtain.

APPENDIX B DOCUMENT REVISION HISTORY

July 2018. Interim revision. A sample Hot Work Permit was updated (Appendix D).

April 2018. Interim revision. Made editorial changes to the post-work fire watch and fire monitoring section.

October 2017. Interim revision. Simplified and combined tables related to post-work fire watch and monitoring periods. Added further torch applied roofing guidance. Added Appendix D, Sample Hot Work Permit. Minor editorial changes were made.

April 2017. Interim revision. Appendix D, *Sample Hot Work Permit*, was deleted, other minor editorial chages were made.

October 2016. The entire data sheet has been revised. The following changes were made:

A. Redirected the emphasis of the data sheet to avoiding hot work whenever possible and, if unavoidable, employing required precautions to control combustible materials.

B. Organized the section on hot work that requires a permit to align with the FM Global Hot Work Permit.

C. Clarified existing and added new recommendations on implementing a hot work management program.

D. Clarified existing and added new recommendations on protecting hot work designated areas at both new and existing locations.

E. Clarified existing and added new recommendations on hot work permit authorization.

F. Clarified existing recommendations on defining a hot work area.

G. Added illustrations to aid in defining a hot work area.

H. Added new recommendations to address the following:

1. Hot work on thermally-conductive surfaces extending through building assemblies

2. Hot work high-risk areas and operations such as on or in combustible-lined equipment, in unprotected areas, and torch-applied roofing

I. Clarified existing recommendations on post-work fire watch responsibilities and durations.

J. Clarified existing recommendations on post-work fire monitoring methods and durations.

K. Added recommendations to address low-energy hot work operations in both production areas routinely conducting low-energy hot work and hot work permit-required areas.

L. Expanded illustrative losses.

M. Added an appendix with a sample hot work management policy statement.

N. Added an appendix with a sample hot work permit (FM Global Hot Work Permit).

October 2013. Editorial changes were made in several sections of the document. The scope was revised. Several definitions were added and/or revised in the glossary.

September 2006. Minor editorial changes were made for this revision.

May 2003. Minor revisions were made to the illustrative losses section.

September 2001. This data sheet has been completely rewritten and supersedes the preceding Data Sheet 9-5/15-1, *Hot Work.*

APPENDIX C SAMPLE HOT WORK MANAGEMENT POLICY

[COMPANY NAME] HOT WORK MANAGEMENT POLICY

This facility has implemented a hot work management program to prevent hot work fires and explosions, and mitigate hot work fires. The program is applicable to both facility employees and contractors conducting hot work anywhere within the facility whether building or equipment installation or alterations. When considering the use of hot work operations, the following steps should be taken: (a) seek alternative cold work methods; (b) consider relocating the work to a hot work designated area; and (c) use a hot work permit when conducting work outside hot work designated areas.

The following hot work operations shall be controlled by the hot work management program.

High-Energy Hot Work	*Low-Energy Hot Work*
[List operations]	[List operations]

The following areas of the facility are defined as hot work designated, hot work production, hot work permit-required, and hot work high-risk.

[List or Insert floor or site plan showing the areas.]

Hot Work Permitting (Minimum Requirements)

1. All hot work permits will be reviewed and authorized by the designated permit authorizer.

2. All contractors will be required to use the facility's hot work permits, including facility authorization (by the designated permit authorizer) and supervision.

3. All facility and contractor personnel conducting hot work, performing fire watch, or fire monitoring will be trained on the hot work permit system at least annually. Permit authorizers will also be trained at least annually.

4. A management audit of the program, including a review of program records and facility changes, will be conducted at least annually.

5. An incident log of all hot work fires will be maintained, in which deficiencies and corrective actions will be identified.

6. Permit-required hot work will be provided with post-work fire watches and fire monitoring periods as shown below.

[Insert list or floor/site plan showing the post-work categorized areas.]

Additional Resources

1.Refer to the following internal procedures for additional requirements and guidance on the hot work management program:

- [List SOPs]

2.Refer to the following external resources for additional hot work management guidance:

- [www.fmglobal.com and/or other websites]

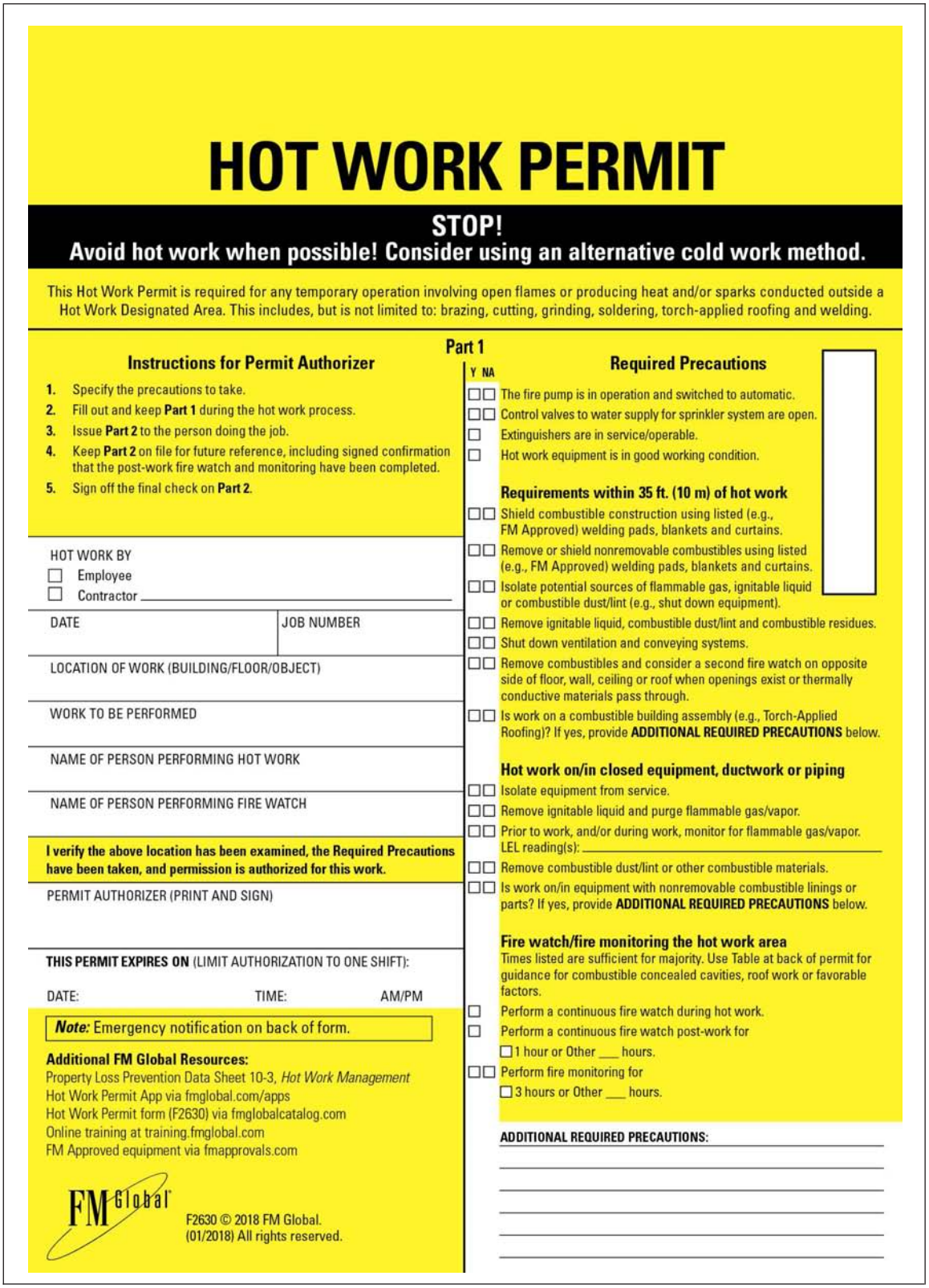
Program Owner:_____ Signature:_____

Manager Endorsing Program:_____Signature:_____

Effective Date of Policy:_____

APPENDIX D SAMPLE HOT WORK PERMIT

Refer to FM Global Resource Catalog (www.fmglobalcatalog.com) to order free copies of the Hot Work Permit.



HOT WORK PERMIT

STOP!
Avoid hot work when possible! Consider using an alternative cold work method.

This Hot Work Permit is required for any temporary operation involving open flames or producing heat and/or sparks conducted outside a Hot Work Designated Area. This includes, but is not limited to: brazing, cutting, grinding, soldering, torch-applied roofing and welding.

Part 1

Instructions for Permit Authorizer

1. Specify the precautions to take.
2. Fill out and keep **Part 1** during the hot work process.
3. Issue **Part 2** to the person doing the job.
4. Keep **Part 2** on file for future reference, including signed confirmation that the post-work fire watch and monitoring have been completed.
5. Sign off the final check on **Part 2**.

HOT WORK BY
☐ Employee
☐ Contractor _____

DATE | JOB NUMBER

LOCATION OF WORK (BUILDING/FLOOR/OBJECT)

WORK TO BE PERFORMED

NAME OF PERSON PERFORMING HOT WORK

NAME OF PERSON PERFORMING FIRE WATCH

I verify the above location has been examined, the Required Precautions have been taken, and permission is authorized for this work.

PERMIT AUTHORIZER (PRINT AND SIGN)

THIS PERMIT EXPIRES ON (LIMIT AUTHORIZATION TO ONE SHIFT):

DATE: TIME: AM/PM

Note: Emergency notification on back of form.

Additional FM Global Resources:
Property Loss Prevention Data Sheet 10-3, *Hot Work Management*
Hot Work Permit App via fmglobal.com/apps
Hot Work Permit form (F2630) via fmglobalcatalog.com
Online training at training.fmglobal.com
FM Approved equipment via fmapprovals.com

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Required Precautions

Y	NA	
☐	☐	The fire pump is in operation and switched to automatic.
☐	☐	Control valves to water supply for sprinkler system are open.
☐		Extinguishers are in service/operable.
☐		Hot work equipment is in good working condition.

Requirements within 35 ft. (10 m) of hot work

☐	☐	Shield combustible construction using listed (e.g., FM Approved) welding pads, blankets and curtains.
☐	☐	Remove or shield nonremovable combustibles using listed (e.g., FM Approved) welding pads, blankets and curtains.
☐	☐	Isolate potential sources of flammable gas, ignitable liquid or combustible dust/lint (e.g., shut down equipment).
☐	☐	Remove ignitable liquid, combustible dust/lint and combustible residues.
☐	☐	Shut down ventilation and conveying systems.
☐	☐	Remove combustibles and consider a second fire watch on opposite side of floor, wall, ceiling or roof when openings exist or thermally conductive materials pass through.
☐	☐	Is work on a combustible building assembly (e.g., Torch-Applied Roofing)? If yes, provide **ADDITIONAL REQUIRED PRECAUTIONS** below.

Hot work on/in closed equipment, ductwork or piping

☐	☐	Isolate equipment from service.
☐	☐	Remove ignitable liquid and purge flammable gas/vapor.
☐	☐	Prior to work, and/or during work, monitor for flammable gas/vapor. LEL reading(s): _____
☐	☐	Remove combustible dust/lint or other combustible materials.
☐	☐	Is work on/in equipment with nonremovable combustible linings or parts? If yes, provide **ADDITIONAL REQUIRED PRECAUTIONS** below.

Fire watch/fire monitoring the hot work area
Times listed are sufficient for majority. Use Table at back of permit for guidance for combustible concealed cavities, roof work or favorable factors.

☐ Perform a continuous fire watch during hot work.
☐ Perform a continuous fire watch post-work for
☐ 1 hour or Other ___ hours.
☐☐ Perform fire monitoring for
☐ 3 hours or Other ___ hours.

ADDITIONAL REQUIRED PRECAUTIONS:

Fig. 7. Hot work permit (page 1)

WARNING

HOT WORK IN PROGRESS! Watch for fire!

Instructions

Person performing hot work: Record time started and display permit at hot work area. After hot work is completed, record time and leave permit displayed for fire watch.

Fire watch: Watch area during hot work and after work completion. Prior to leaving area, perform final inspection, sign, leave permit displayed and notify Fire Monitor or Permit Authorizer.

Fire Monitor: Monitor area after post-work fire watch completion. Perform final inspection, sign and return to Permit Authorizer.

HOT WORK BY
☐ Employee
☐ Contractor _____

DATE | JOB NUMBER

LOCATION OF WORK (BUILDING/FLOOR/OBJECT)

WORK TO BE PERFORMED

NAME OF PERSON PERFORMING HOT WORK

NAME OF PERSON PERFORMING FIRE WATCH

I verify the above location has been examined, the Required Precautions have been taken, and permission is authorized for this work.

PERMIT AUTHORIZER (PRINT AND SIGN)

THIS PERMIT EXPIRES ON (LIMIT AUTHORIZATION TO ONE SHIFT):

DATE: TIME: AM/PM

Hot Work Date:	Start Time: Finish Time:	am/pm am/pm
Post-Work Fire Watch Name	Finish Time:	am/pm
Fire Monitor ☐ Person ☐ Other Name/Other	Finish Time:	am/pm
Final Check Name	Time:	am/pm

Part 2

Required Precautions

Y NA

☐☐ The fire pump is in operation and switched to automatic.
☐☐ Control valves to water supply for sprinkler system are open.
☐ Extinguishers are in service/operable.
☐ Hot work equipment is in good working condition.

Requirements within 35 ft. (10 m) of hot work

☐☐ Shield combustible construction using listed (e.g., FM Approved) welding pads, blankets and curtains.
☐☐ Remove or shield nonremovable combustibles using listed (e.g., FM Approved) welding pads, blankets and curtains.
☐☐ Isolate potential sources of flammable gas, ignitable liquid or combustible dust/lint (e.g., shut down equipment).
☐☐ Remove ignitable liquid, combustible dust/lint and combustible residues.
☐☐ Shut down ventilation and conveying systems.
☐☐ Remove combustibles and consider a second fire watch on opposite side of floor, wall, ceiling or roof when openings exist or thermally conductive materials pass through.
☐☐ Is work on a combustible building assembly (e.g., Torch-Applied Roofing)? If yes, provide **ADDITIONAL REQUIRED PRECAUTIONS** below.

Hot work on/in closed equipment, ductwork or piping

☐☐ Isolate equipment from service.
☐☐ Remove ignitable liquid and purge flammable gas/vapor.
☐☐ Prior to work, and/or during work, monitor for flammable gas/vapor. LEL reading(s): _____
☐☐ Remove combustible dust/lint or other combustible materials.
☐☐ Is work on/in equipment with nonremovable combustible linings or parts? If yes, provide **ADDITIONAL REQUIRED PRECAUTIONS** below.

Fire watch/fire monitoring the hot work area

Times listed are sufficient for majority. Use Table at back of permit for guidance for combustible concealed cavities, roof work or favorable factors.

☐ Perform a continuous fire watch during hot work.
☐ Perform a continuous fire watch post-work for
☐ 1 hour or Other ___ hours.
☐☐ Perform fire monitoring for
☐ 3 hours or Other ___ hours.

ADDITIONAL REQUIRED PRECAUTIONS:

_____
_____
_____
_____
_____

Fig. 7. Hot work permit (page 2)

WARNING

HOT WORK IN PROGRESS!
Watch for fire!

In case of emergency, call the contacts listed below before attempting to extinguish the fire.

Contact	Number

Construction and Occupancy Factors for Post-Work Fire Watch and Monitoring Periods

		Construction Factors					
		Noncombustible construction, or FM Approved Class 1 or Class A building materials		Combustible construction without concealed cavities		Combustible construction with unprotected concealed cavities	
		Watch	Monitor	Watch	Monitor	Watch	Monitor
Occupancy Factors	Noncombustible with any combustibles contained within closed equipment (e.g., ignitable liquid within piping)	30 minutes	0 hours	1 hour	3 hours	1 hour	5 hours
	Office, retail or manufacturing with limited combustible loading	1 hour	1 hour	1 hour	3 hours	1 hour	5 hours
	Manufacturing with moderate to significant combustible loading except as noted below	1 hour	2 hours	1 hour	3 hours	1 hour	5 hours
	Warehousing	1 hour	2 hours	1 hour	3 hours	1 hour	5 hours
	Exceptions: Occupancies with processing or having bulk storage of combustible materials capable of supporting slow-growing fires (e.g., paper, pulp, textile fibers, wood, bark, grain, coal or charcoal)	1 hour	3 hours	1 hour	3 hours	1 hour	5 hours

When performing torch-applied roofing, apply additional precautions and conduct a minimum 2 hours fire watch and 2 hours fire monitoring. If an infrared camera is utilized, reduce to a 1 hour fire watch and 1 hour fire monitoring.

When performing hot work on/in equipment containing nonremovable combustible linings or parts, apply additional precautions and conduct a minimum 1 hour fire watch and 3 hours fire monitoring within the equipment, and in the surrounding areas per Table above.

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Fig. 7. Hot work permit (page 3)