7
Permit-to-Work Systems

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7.1
Introduction

Workplace hazards should be eliminated whenever possible or the appropriate safeguards put in place to protect the worker(s). However, under certain non-routine types of work, the normal safeguards may be disabled or new hazards may be introduced. A permit-to-work (PTW) is a formal written administrative procedure for controlling hazards in these situations. The permit process requires stringent checks and specific permission before such work tasks, which would normally be prohibited, are undertaken. The permitting process involves detailed planning between site management, operators, outside contractors, and other involved parties, assessing the risk, putting together a hazard control plan, designating the personnel who will be involved, and establishing step-by-step procedures so that the work is done safely. A PTW by itself does not prevent injuries. It requires competent individuals, proper planning, a well thought out hazard analysis, and proper checks in order to be successful. Work tasks that might require a PTW include work involving liquids or gases under pressure, toxic materials, corrosive materials, flammable materials, hot materials, oxygen deficiency, open flames or arcs, flying particles or sparks, electricity, radioactivity, asbestos, confined space, explosives, fall protection, and moving machinery.

7.2
The Permit-to-Work Process

In very simple situations, a worker is assigned a task for which a PTW is required. Table 7.1 is an example of a basic PTW form that should be completed. The worker then goes to a supervisor or other *authority* to obtain a permit, fills it out, and returns it to the supervisor. NFPA 51B defines a permit *authorizing individual* as the individual designated by management to authorize the work. A *qualified person* does a risk assessment of the work and determines the hazard control measures necessary to do the work. ANSI (2009) Z117.1 defines a *qualified person* as

Handbook of Loss Prevention Engineering, First Edition. Edited by J. M. Haight.

Table 7.1 Sample permit to work.

1. **Permit title**	2. **Permit number**
3. **Job location**	
4. **Plant location**	
5. **Description of work**	
6. **Hazard identification**	
7. **Precautions necessary and actions in the event of an emergency**	
8. **Personal protective equipment (PPE)**	
9. **Issue** signature of issuing authority confirming that isolations have been made and precautions taken	
10. **Acceptance** signature confirming understanding of the work to be done	
11. **Extension/shift handover procedures** – signatures confirming that plant remains safe and new permit authority made aware of hazards and precautions	
12. **Handback** signature of performing authority that the work has been completed and signature of issuing authority that work has been completed	
13. **Cancellation**	

Source: Hughes and Ferrett (2007).

a person who, by reason of training, education, and experience, is knowledgeable in the operation, and competent to evaluate the hazards and specify controls. The authorized person should personally inspect the site to be sure the proposed precautions have been taken (Hughes and Ferrett, 2007). Once the permit has been reviewed, approved, and signed by the approval authority, it is made available to those doing the work. This is most easily done by posting it in the area where the work is to be done so that the person(s) who need to be aware can readily refer to it. When the work has been completed, the permit is returned to the approval authority for cancellation and filing.

The PTW should generally include the following (OGP, 1993):

- title and permit number
- description of the work to be done
- description of the exact location where the work is to be done
- list of the personnel and the tools involved
- list of the potential hazards
- the safety precautions to be taken
- the details of personal protective equipment (PPE) that should be worn
- the date of issuance and the period when the permit is valid
- the signature of the person in charge
- the signature of the person issuing the permit
- the signature of handover of responsibilities between shifts
- declaration by the person in charge that the work is complete, or incomplete, and that the site has been left in a safe condition
- the signature of the person issuing the permit.

The implementation of a PTW may require the involvement of a number of people, each with a specific responsibility or role, as listed in Table 7.2. There

Table 7.2 Responsibilities within a PTW system.

Title	Role
Originator	Person requiring the job to be done
Permit user	Person working under the terms of the permit (also known as competent person)
Permit authorizer	Person authorizing the permit
Issuing authority	Person issuing the permit (might be a shift supervisor)
Performing authority	Person accepting the permit on behalf of the permit user (this could be the person in charge of the work)
Area authority	Person in control of the site where the work is to be done
Site checker	Person carrying out checks required by permit, for example, a gas tester
Isolating authority	Person(s) responsible for making electrical, mechanical, process, or other energy isolations

Source: HSE (2005).

can be variation in the titles and responsibilities depending on the task, the site, and the complexity of the work. The same person can fulfill more than one role.

There may also be s*pecialists* involved in the permitting process, such as industrial hygienists or engineers whose role would be to provide advice to management or monitor the work environment. If outside *contractors* are involved, the PTW should also be applied to them. However, the overall responsibility should rest with the site manager (Hughes and Ferrett, 2007).

There a number of other factors which can contribute to a failure of the PTW system, such as:

- failure to recognize a hazard
- communication failure
- untrained workers
- poor management of the PTW
- insufficient monitoring of the PTW
- language barriers.

Assessment of the hazards that may be involved is critical. First, the specific details of the work to be done should be obtained. The hazards associated with the material being handled and the equipment that is to be used should be considered. Potential physical hazards should be considered. A list of physical hazards that should be considered include (OGP, 1993):

- liquids or gases under pressure
- toxic materials
- corrosive materials
- flammable materials
- hot materials

- oxygen deficiency
- flames, arcs, or sparks
- electricity
- crane operation
- radioactivity
- moving machine parts
- fall hazards
- confined space
- explosives
- weather conditions.

Once the hazard(s) have been identified, controls should be implemented to eliminate the hazard or reduce the risk to an acceptable level. The hazard controls, which may include PPE, should be recorded on the permit.

The difficulty of carrying out the work is another factor. The impact of the work on the surrounding environment should also be assessed.

Oversight of the permit process is important. The site management should provide the permit approval authority so that oversight can be maintained. The permit should be monitored to ensure that the conditions under which the permit was originally issued have not changed. The permit planning process should anticipate and provide for contingencies. For example, the implementation of a PTW can break down during shift changeovers. Site management should plan the shift change so that there is sufficient overlap between personnel to allow for a status review prior to handing the permit over to the next shift. Only competent workers who are trained in the work task and the permitting process should be allowed to do the work.

Work can be interrupted by an emergency. All work must cease during an emergency. The permit should provide for actions to be taken during an emergency.

The use of outside contractors presents another potential problem. Facility and maintenance work may be outsourced for many reasons. For example, site management may not have the manpower or may not have the expertise. Small retail establishments, small manufacturers, and small apartment complexes are some examples of enterprises that may lack even basic knowledge of the PTW process and the potential hazards. Even with more sophisticated establishments, there is a tendency for site management to be more relaxed with outside contractors, assuming they know their jobs (FM Global, 2006). FM Global has found that at least in the case of hot work, the risk of a fire increases over 100% when site supervision of outside contractors is absent (FM Global, 2006).

Before any work is started, the outside contractor(s) and the site management should discuss the project and the hazards. The contractor(s) and management should recognize that they have a mutual responsibility to ensure the work is done safely. A site employee should be assigned to supervise outside contractors directly (FM Global, 2006). Site management should have final sign-off on any PTW (Hughes and Ferrett, 2007).

7.3 Regulations and Standards

The Occupational Safety and Health Administration (OSHA) is the enforcement agency for workplace safety and health in the United States. The Code of Federal Regulations CFR 1910 addresses health and safety for general industry and CFR 1926 covers construction. The requirements for permit-required confined spaces are provided in 29 CFR 1910.146. The American National Standards Institute (ANSI), the American Petroleum Institute (API), and the National Fire Protection Association (NFPA) promulgate detailed safety standards for specific types of operations that require a permit.

In the United Kingdom, the legal requirements relative to PTW systems include:

- Health and Safety at Work Act 1974
- Confined Spaces Regulations 1997
- Control of Major Accident Hazards Regulations (COMAH) 1999
- Control of Substances Hazardous to Health Regulations (COSHH) 2002
- Dangerous Substances and Explosive Atmospheres Regulations 2002
- Electricity at Work Regulations 1989
- Ionizing Radiations Regulations 1999
- Management of Health and Safety at Work Regulations 1999
- Offshore Installations Regulations 1995
- Offshore Installations and Wells Regulations 1996
- Pipelines Safety Regulations 1996
- Pressure Systems Safety Regulations 2000
- Provision and Use of Work Equipment Regulations 1998.

7.4 Hot Work

NFPA 51B defines "hot work" as "work involving burning, welding, or a similar operation that is capable of initiating fires or explosions." Any work activity that produces flames, sparks, or heat will fall into this category. Examples of hot work include cutting, welding, grinding, hot riveting, soldering, torch-applied roofing, and brazing. Even heat sources with low temperature ratings could still ignite materials and cause a fire.

Four factors should be considered when hot work is contemplated:

1) The three sides of the fire triangle, a source of ignition, air to support combustion, and a combustible material.
2) The shop's familiarity with hot work. A shop that is seldom involved with hot work may not be familiar with the safety planning that is involved. A shop that does hot work on a routine basis may become complacent.
3) The process and equipment that are involved.
4) The supervision and training of the operator.

Consideration should be given to replace hot work with other processes, for example, use manual hydraulic shears or a mechanical pipe cutter instead of torch or saw cutting. Consider using mechanical bolting instead of welding. Instead of sweat soldering pipes, use screwed or flanged pipe. Use mechanically attached roofing systems instead or torch-applied systems.

It is very important that nothing is taken for granted when contemplating hot work. Although some combustible materials may be apparent, others may not. For example, combustibles in concealed wall and floor spaces, dust above suspended ceilings, and the accumulation of flammable vapors are potential hidden hazards that should be considered.

Combustibles should be isolated or protected. Move combustibles to a safe distance, at least 35 ft away. Be sure there are no openings in walls, ceilings, or floors within a 35 ft radius. If this is not possible, then be alert for cutting conditions that could propel sparks overhead or downwards. Protect the exposed combustibles with fire-resistant guards and provide a trained fire watch with extinguishing equipment.

Protect combustible floors with wet sand, sheet metal, or approved blankets. Trash or oily rags should be removed from the area. Cover any combustibles that cannot be moved with approved blankets or welding curtains. Lock off openings in ducts to prevent sparks from traveling to other areas where combustibles might be located. Close all doors and fire doors. Cover openings in walls, floor, and ceilings. If the work is to be done in an elevated area, such as the underside of a roof or a mezzanine, place an approved blanket under the work area.

Processes that involve combustible dusts, flammable liquids, or flammable gases require special precautions. The tanks, process vessels, and other process equipment should be shut down, cleaned, and purged of combustible materials. The contents should be identified. If the contents are unknown, then it should be assumed that the material is potentially explosive. The container should be drained and cleaned using an appropriate method. In many situations, the container must be purged with an inert gas, steam, or water. The interior of the container should be tested with a combustible gas detector to make sure that the cleaning and/or purging operation has made the container safe. Figure 7.1 shows a portable multi-gas detector that can be used to monitor for explosive gases. This testing should be done immediately before the beginning of hot work and periodically during the work. After purging, ventilation should maintain the atmosphere in the tank or enclosure below 25% of the lower explosion limit (FM Global, 2000).

Site management is responsible for hot work and informing all contractors about site-specific flammable materials, processes, and fire hazards. Management should designate an authorizing individual to authorize the hot work. The authorizing individual shall determine site-specific flammable materials and hazardous processes, ensure the protection of combustibles from ignition, fire protection, and extinguishing equipment, and establish a fire watch. A fire watch is required when combustibles are closer than 35 ft from the operation, if combustibles are easily ignited by sparks, if wall or floor openings within a 35 ft radius will expose combustibles in adjacent areas, or if combustibles are adjacent to the opposite

Figure 7.1 Multi-gas detector. A multi-gas detector can be used to monitor for explosive atmospheres. (Photograph courtesy of Safety, Inc.)

side of walls, partitions, or roofs that may be ignited. The fire watch shall have the authority to stop the hot work if unsafe conditions arise. The hot work operator shall have the authority's approval before starting work and shall cease work if hazardous conditions arise. Table 7.3 is a sample hot work permit based on NFPA 51B.

FM Global suggests the following hot work permit system practice:

- The fire safety supervisor confirms the location of the proposed hot work and verifies that the necessary safety precautions have been taken.
- The fire safety supervisor signs and issues the permit only after all fire prevention precautions have been implemented and a fire watch is present.
- The hot work permit is posted in a visible place in the work area.
- The fire watch maintains constant vigil, watches sparks, smoldering flames, or other fire hazards, and is ready to provide an initial fire response.
- Once the work is completed, the fire watch remains in the area for 1 h, carefully inspecting the work and the adjacent areas. The fire watch then signs the permit and leaves it posted and informs the fire safety supervisor.
- The hot work area is then monitored for an additional 3 h after the 1 h fire watch.
- When the monitoring period has ended, the safety supervisor conducts a final inspection, signs the permit, and retains the permit as a record of the work.

As discussed earlier, hot work performed by outside contractors indicates that the risk of a fire can increases over 100% when there is no site supervision, and one out of every three fires involving hot work occurs when outside contractors are involved (NFPA, 2008). Contractors often do not understand the fire hazards and how their work can lead to a fire. For that reason, outside contractors performing hot work should be directly supervised by a site employee. Contractors should not be allowed to authorize their own hot work permits (FM Global, 2006).

Table 7.3 Sample hot work permit.

1. **Permit title** 2. **Permit number** 3. **Date**
4. **Job location**
5. **Plant location**
6. **Description of work to be done**
7. **Signature of person doing hot work**
8. **Signature of permit-authoring individual** signature verifies that the location has been examined, precautions taken, and permission is granted to do the work
9. **Time started ________ Time completed _________**

PERMIT IS GOOD FOR ONE DAY ONLY

- ☐ Available sprinklers, hose streams, and extinguishers are in service and operable
- ☐ Hot work equipment is in good working condition in accordance with manufacturer's specifications
- ☐ Special permission obtained to conduct hot work on metal vessels or piping lined with rubber or plastic

Requirements within 35 ft of hot work

- ☐ Flammable liquid, dust, lint, and oily deposit removed
- ☐ Explosive atmospheres in area eliminated
- ☐ Floors swept clean and trash removed
- ☐ Combustible floors wetted down or covered with damp sand or fire-resistive/non-combustible materials or equivalent
- ☐ Personnel protected from electrical shock when floors are wet
- ☐ Other combustible storage material removed or covered with listed or approved materials
- ☐ All wall and floor openings covered
- ☐ Ducts and conveyors that might carry sparks to distant combustible material covered, protected, or shutdown

Requirements for hot work on walls, ceilings, or roofs

- ☐ Construction is non-combustible and without combustible coverings or insulation
- ☐ Combustible material on other side of walls, ceilings, or roofs is moved out of the area

Requirements for hot work on enclosed equipment

- ☐ Enclosed equipment is cleaned of all combustibles
- ☐ Containers are purged of flammable liquid/vapor
- ☐ Pressurized vessels, piping, and equipment are removed from service, isolated, and vented

Requirements for hot work fire watch and fire monitoring

- ☐ Fire watch is provided during and for a minimum of 30 min after hot work, including any break activity
- ☐ Fire watch is provided with suitable extinguishers and, where practical, a charged small hose
- ☐ Fire watch is trained in use of equipment and in sounding alarm
- ☐ Fire watch can be required in adjoining areas, above and below

Source: NFPA 51B.

The following case study (FM Global, 2006) illustrates what can happen with outside contractors when the plant's hot work permit system is not followed:

> A contractor was welding in a chicken processing plant. Automatic sprinklers were being installed but were not yet in service. The wall consisted of polystyrene board covered with fiberglass-reinforced plastic. Polyurethane insulation was sprayed on to a lap-seam steel-on-steel roof. The contractors were welding within 4 in of the combustible insulation. The wall insulation caught fire and spread to the roof insulation. A 28 000 ft^2 area of the roof collapsed. The fire also spread to the maintenance shop, motor control center, and corrugated box storage areas. The loss was estimated at $25 million. The plant's hot work permit system was not followed. A fire watch was not posted and there were no fire extinguishers.

The following case study emphasizes the need to purge a tank or container before beginning hot work (NFPA 51B) (NFPA, 2009a):

> Workers were welding supports on a 6000 gallon vertical tank containing 3000 gallons of alcohol. Heat was transmitted through the metal of the tank and ignited alcohol vapor inside. The tank was blown into the air.

7.5 Confined Space

A *confined space* is an enclosed area large enough to allow a person to enter a space not designed for continuous human occupancy, has a function other than human occupancy, and has a restricted entry and exit (OSHA 1910.146(b)). Examples of confined spaces include railroad cars, tanks, silos, incinerators, elevator pits, boilers, vessels, pipelines, ducts, sewers, manholes, pits, flues, excavations, reactors, and ovens. Figure 7.2 shows telecommunications and electrical utility work performed in a manhole which is considered a confined space. Work in confined spaces includes cleaning, painting, welding, and electrical work. There are non-permit confined spaces and permit-required confined spaces.

A *non-permit confined space* does not contain a hazardous atmosphere or have the potential to contain a hazardous atmosphere. There are only secondary hazards which are not anticipated to cause death or other serious physical harm under normal operating conditions (OSHA 1910.146(b)). This can change depending on the activities. For example, welding or the use of chemicals can change this classification. It is therefore important to monitor confined space work continually in the event that hazards are introduced that could change the classification from non-permit to permit.

A *permit-required confined space* has a hazardous atmosphere or the potential to have a hazardous atmosphere. It may contain material that can engulf the entrant. A permit-controlled space has an internal configuration that could entrap or cause the entrant to be asphyxiated. There can also be other recognized health

Figure 7.2 Work in a manhole. Telecommunications and electrical utility work performed in manholes is considered work in a confined space.

hazards that may cause death or serious harm (OSHA 1910.146(b)). By definition, a permit-required confined space requires a PTW.

The hazards associated with working in a confined space include the presence of toxic substances, flammable vapors, inadequate oxygen, mechanical hazards, ingress of fluids, and engulfment in unstable materials, such as grains or flour, and elevated temperatures. All energy sources which are potentially dangerous should be isolated or relieved, then locked out or tagged out. These hazards include pipelines, machines, and electrical, hydraulic, thermal, and pneumatic energy.

A qualified person should conduct an initial survey of the operation and identify the potential hazards. Each hazard must be evaluated with consideration to the scope of the hazard, the magnitude of the hazard, the likelihood of an occurrence, the consequences of an occurrence, the potential for changing conditions, the strategy for controlling the hazard(s), and the need for an emergency response plan. The hierarchy of engineering controls should be followed for hazard control: eliminate the hazard, provide safety devices, institute administrative procedures, or provide PPE. Possible changes in activities in the space or other change which could adversely affect the confined space should be considered. There could be changes in work activities that were not included in the PTW. For example, a decision to weld in a confined space might be made after the work begins. A new PTW would be required in this case.

Atmospheric testing should be done before entry into a confined space. Initial testing should be done with the ventilation system off to simulate the conditions in the event of a ventilation system failure. Additional testing should be done with the ventilation system turned on. The entry team should include an attendant, the entrant, and the entry supervisor. The attendant(s) should be stationed outside the point of entry/exit. The duties of the attendant(s) include providing assistance to entrants, directing the entrants to exit the confined space when unanticipated hazards arise, initiating emergency evacuation, monitoring the situation for conditions which could adversely affect the entry, maintaining communication with the entrant(s), and preventing unauthorized entry.

The entrant(s) should be able to recognize hazards, respond to emergencies, recognize symptoms and warning signs of relative hazards, and notify the attendant(s) of any emergencies in the space. The entry supervisor shall verify that all precautions have been taken prior to endorsing the permit and allowing entry and verify that rescue services are available. The entry supervisor shall terminate entry and assure removal of personnel if a problem arises.

There should be a written plan to address emergency response and evacuation, retrieval, or rescue of any member of the entrant team. This is very important because conditions could change in a confined space or there may be a failure in the hazard control procedures. There are three types of rescue (Cal/OSHA, 2011). *Self-rescue* is the preferred plan because confined space hazards can develop very rapidly. *Non-entry rescue* is the next best approach because it does not expose or put at risk additional personnel. *Entry rescue* involves rescuers entering the space to retrieve the entrant(s). Rescue equipment would include a vertical retrieval system, a ladder, head protection, SCBA/SAR gear, and explosion-proof lighting. Figure 7.3 is a sample confined space PTW based on OSHA 1910.146, Appendix D.

The following case study illustrates the importance of training workers in confined space work, posting DANGER: PERMIT-REQUIRED CONFINED SPACE – DO NOT ENTER signs, and taking steps to prevent unauthorized entry into a confined space (NIOSH, 2008):

> A 59-year-old male employee was found dead at a fruit storage facility after he entered a controlled atmosphere (CA) apple storage room. The atmosphere contained less than 3% oxygen (O_2). The storage room had a large wooden outer door and an interior aluminum door. The interior door had been sealed with caulking and weather stripping. There was a Danger, Do Not Enter sign affixed to the door. The door had a 2 foot by 3 foot Plexiglas window attached with 18 bolts and wing nuts for visual observation of the produce. The worker removed the wing nuts and the Plexiglas window and climbed through the door opening, and entered the CA room. He was found by the owner collapsed on the floor.

This case study illustrates the importance of following a confined space PTW work system including emergency response and rescue workers (Cal/OSHA, 2011):

> A worker entered a wastewater treatment tank to clean its interior. The tank contained toxic acids and cyanide sludge. The worker was overcome by cyanide gas. When a second worker went into the tank to rescue his co-worker, he was also overcome by the gas and died.

7.6 Live Line Electrical Work

Whenever possible, work on electrical equipment should be done after the circuits have been de-energized and put in an electrically safe condition with a lock out/tag

Confined Space Entry Permit

Date and Time Issued: _______________ Date and Time Expires: ________
Job site/Space I.D.: ________________ Job Supervisor:________________
Equipment to be worked on: __________ Work to be performed: _________
Stand-by personnel: __________________ ________________ _____________

1. Atmospheric Checks: Time ________
Oxygen ________%
Explosive ________% L.F.L.
Toxic ________PPM

2. Tester's signature: _____________________________

3. Source isolation (No Entry):

	N/A	Yes	No
Pumps or lines blinded,	( )	( )	( )
disconnected, or blocked	( )	( )	( )

4. Ventilation Modification:

	N/A	Yes	No
Mechanical	( )	( )	( )
Natural Ventilation only	( )	( )	( )

5. Atmospheric check after isolation and Ventilation:
Oxygen __________% > 19.5 %
Explosive _______% L.F.L < 10 %
Toxic ___________PPM < 10 PPM H(2)S
Time ____________
Testers signature: _____________________________

6. Communication procedures: ____
____

7. Rescue procedures: ____
____
____
____

8. Entry, standby, and back up persons:

	Yes	No	
Successfully completed required training?	( )	( )	
Is it current?		( )	( )

9. Equipment:

	N/A	Yes	No	
Direct reading gas monitor -tested	( )	( )	( )	
Safety harnesses and lifelines for entry and standby persons	( )	( )	( )	
Hoisting equipment	( )	( )	( )	
Powered communications	( )	( )	( )	
SCBA's for entry and standby persons	( )	( )	( )	
Protective Clothing	( )	( )	( )	
All electric equipment listed Class I, Division I, Group D and Non-sparking tools		( )	( )	( )

10. Periodic atmospheric tests:

Oxygen	____%	Time ____	Oxygen	____%	Time ____
Oxygen	____%	Time ____	Oxygen	____%	Time ____
Explosive	____%	Time ____	Explosive	____%	Time ____
Explosive	____%	Time ____	Explosive	____%	Time ____
Toxic	____%	Time ____	Toxic	____%	Time ____
Toxic	____%	Time ____	Toxic	____%	Time ____

We have reviewed the work authorized by this permit and the information contained here-in. Written instructions and safety procedures have been received and are understood. Entry cannot be approved if any squares are marked in the "No" column. This permit is not valid unless all appropriate items are completed.

Permit Prepared By: (Supervisor)____
Approved By: (Unit Supervisor)____
Reviewed By (Cs Operations Personnel) :
_________________________________ ____________________________________
(printed name) (signature)

This permit to be kept at job site. Return job site copy to Safety Office following job completion.

Copies: White Original (Safety Office)
Yellow (Unit Supervisor)
Hard(Job site)

Figure 7.3 Sample confined space permit. (Source: OSHA 1910.146, Appendix D.)

Figure 7.4 Multiple locks used to lockout a switch gear cabinet.

Figure 7.5 Electric linemen may work on electrically energized or de-energized power lines.

out procedure (Weigel, 2010) implemented. Figure 7.4 shows multiple locks used to lock out a switch gear cabinet. Each employee involved in the maintenance work would apply their own separate lock.

However, there are scenarios under which work must be done on or near energized circuits. For example, electrical utilities need to maintain and replace their electrical equipment while still providing service to their customers. Electric linemen frequently work on electrically energized power lines (Figure 7.5). Live line work on substations that provide hospitals, fire stations, and law enforcement may be the only alternative unless backup generators are available. Companies may prefer to do live work in a particular part of a plant rather than shutting the entire plant down.

Work on energized circuits is extremely dangerous and should done only when the circuit cannot be de-energized using lock out/tag out procedures, the circuit must be in an energized state, and there are no safer alternatives. It should be emphasized that work both *on* and *near* energized circuits is hazardous and should

Table 7.4 Sample live work permit.

1. **Permit title**	2. **Permit number**
3. **Job location** be specific to the circuit, equipment, location	
4. **Plant location**	
5. **Description of work**	
6. **Justification as to why circuit/equipment cannot be de-energized**	
7. **Signature of person requesting permit**	
8. **Description of work**	
9. **Description of safe work practices to be employed**	
10. **Results of shock hazard analysis**	
11. **Determination of shock protection boundaries**	
12. **Results of arc flash analysis**	
13. **Determination of arc flash protection boundary**	
14. **Precautions necessary and actions in the event of an emergency**	
15. **Personal protective equipment (PPE)**	
16. **Means to restrict access of unqualified persons from work area**	
17. **Evidence of completion of a job briefing**	
18. **Signature of electrically qualified person(s) that the above-described work can be done safely**	
19. **Approval signatures** (manufacturing manager, safety manager, general manager, etc.)	

Source: NFPA 70E.

be considered live work requiring a PTW. NFPA 70E is the most comprehensive standard regarding electrical hazards (Floyd, 2010). A sample live line electrical PTW is provided in Table 7.4 based on NFPA 70E.

There are four basic types of live line electrical work (EPRI, 2004):

- De-energized work – once a circuit has been disconnected from all known electrical sources, the circuit should still be considered energized until all system, equipment, and personal protective grounds have been installed.
- Gloving – energized circuits are worked on using insulating gloves, blankets, line hoses, or other cover-up equipment.
- Insulating tool work – work is done with insulating tools, non-conductive rope, and aerial devices.
- Contact work – the worker is in direct contact with energized parts and is separated from ground by air and a combination of insulating tools.

Common work that could involve live line electrical work includes:

- insulator cleaning
- bus repair
- replacement, repair, or installation of new equipment
- vegetation management
- switch alignment with one side energized
- testing or work near energized equipment.

There are three types of electrical hazards: electrical shock, arc flash, and arc blast (NFPA 70E) (NFPA, 2009b). *Electrical shock* occurs when electric current passes through the human body. This can occur if a worker comes in contact with both wires of an electric circuit or contacts one wire of a circuit and ground. However, at high voltages, it is not necessary to contact energized equipment directly to receive an electrical shock. There is an electrical field around all charged devices. When a conducting object, such as the human body, is brought near to the device, the field can intensify enough that the air breaks down and an arc can jump from the device to ground through the person. Even rubber is subject to electrical failure if the electrical field is high enough (EPRI, 2004). For this reason, minimum safe operating distances from conductors are specified in NFPA 70E for work near energized conductors.

An *arc flash* is an electrical breakdown of the electrical resistance of air. This can occur when there is high enough voltage in a system and a path to ground. Large electrical currents pass through the air resulting in a massive release of energy. The energy can vaporize metal conductors, creating hot vapors and disbursing hot metal. Arc flashes can kill at a distance of 10 ft (NFPA 70E). Arc flash protection boundaries are specified in NFPA 70E.

The tremendous temperatures of an electrical arc can also cause an *arc blast*. The rapid thermal heating of the air and vaporization of metal can create very high pressures. The physical hazards from an arc blast include high pressure, high sound levels, and shrapnel (NFPA 70E).

Work on energized electrical conductors or circuits that operate at greater than 50 V requires a PTW. The energized work permit should include (NFPA 70E):

1) a description of the circuit, the equipment to be worked on, and the location
2) justification as to why the work must be done in an energized condition
3) a description of the safety work practices
4) results of the shock hazard analysis
5) determination of the shock protection boundaries
6) results of the arc flash hazard analysis
7) the arc flash protection boundary
8) the necessary PPE
9) means employed to restrict the access of unqualified persons from the work area
10) evidence of completion of a job briefing
11) signature(s) of work approval authority.

A shock hazard analysis should be done to determine the voltage to which personnel will be exposed, the boundary requirements, and the PPE. Shock protection boundaries for various system voltages are listed in Table 130.2(c) of NFPA 70E.

An arc flash analysis should be done to establish the arc flash protection boundary. Information on estimating the arch flash protection boundary can be found in Annex D of NFPA 70E. An arc flash analysis is not required whenever the following conditions exist:

1) The circuit is rated 240 V or less.
2) The circuit is supplied by one transformer.
3) The transformer supplying the circuit is rated less then 125 kVA.

When outside contractors are used, the utility or site management should ensure that all electrical workers are qualified and certified. Written work procedures and a hazard analysis should be provided to the utility or site management by the contractor. A PTW is still required so that the authorizing authority can understand the scope of the work and how it might affect the facility and its employees.

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