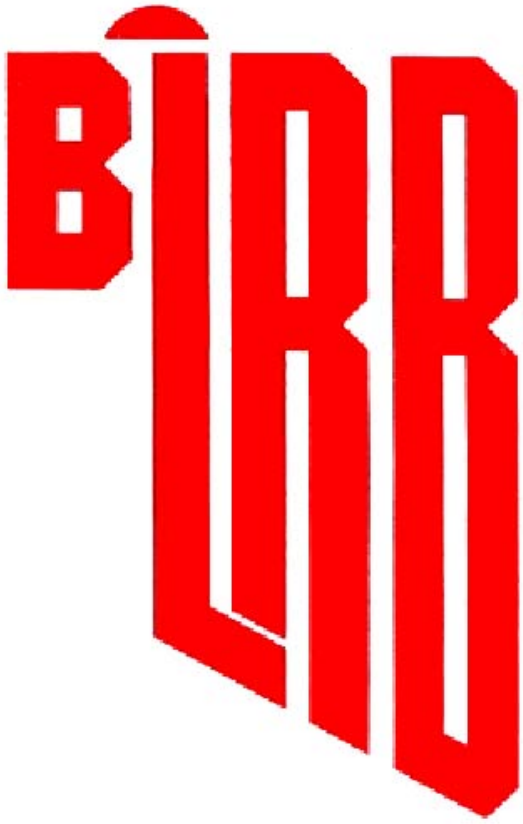

RECOMMENDED GOOD PRACTICE

SAFE FIRING OF AUXILIARY FUEL IN BLACK LIQUOR RECOVERY BOILERS

THE BLACK LIQUOR RECOVERY BOILER ADVISORY COMMITTEE

February 2012

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FOREWORD

The black liquor recovery boiler presents problems of operation and safety that far exceed those of the conventional power boiler. It is primarily a chemical recovery process unit in which the organic materials in the black liquor are burned while the oxidized sulfur compounds of sodium and potassium are reduced and drained as molten smelt from the furnace bottom. At the same time the heat released is used for steam generation.

While most of the heat for this process is provided from burning the black liquor, additional heat from gas or oil fired auxiliary fuel burners is needed to start up the unit, regulate the char bed, avoid blackouts and to furnish additional steam.

The complexity of the process and the severe environment combine to present a formidable challenge to operators of recovery boilers. In most cases the recovery boiler operator must depend to a large degree on the thoroughness of their training, their own personal senses and reactions and instrumentation to aid in safe operation. Many times the operators are forced to evaluate a situation rapidly, and it is hoped, correctly, without having all the facts. The burden on the recovery operator is truly great and the industry has realized that they must have help, guidance, and proper tools to promote safety and boiler availability.

The continuing occurrence of furnace explosions emphasizes the constant need for action by industry, equipment manufacturers and insurance interests alike. The causes of furnace explosions have been:

1. Reaction between water and molten smelt.

2. Reaction between low solids liquor and molten smelt.

3. Uncontrolled ignition of an accumulation of unburned fuel from the auxiliary burners.

4. Uncontrolled ignition of an accumulation of unburned gases from pyrolyzed black liquor.

In January 1962, the Black Liquor Recovery Boiler Advisory Committee was formed by representatives of the pulp and paper industry, manufacturers of black liquor recovery boilers and insurance companies providing coverage on black liquor recovery boilers. The purpose of the committee was stated as follows:

> To work toward improving the safety of recovery boilers and/or furnaces and their auxiliaries through the interchange of technical knowledge, experience and data on prior and any future casualties.

The Committee established the *Safe Firing of Auxiliary Fuel in Black Liquor Recovery Boilers Subcommittee* to review the unique conditions required to safely fire auxiliary fuel in recovery boilers. This Subcommittee has prepared the following *Recommended Good Practice, Safe Firing of Auxiliary Fuel in Black Liquor Recovery Boilers* to share accumulated knowledge and experience in the interest of improving recovery boiler operating safety.

CHANGES

February 2012

"Notice of Disclaimer of Liability" has been added to page 2.

For a summary of prior changes to this document refer to Appendix A, Document Revision History.

CHAPTER 1 GENERAL

1.1 Basic Causes of Auxiliary Fuel Explosions

The basic cause of an explosion is the ignition of an accumulated combustible mixture within the confined space of the furnace, boiler gas passes, ductwork and fans that convey the gasses of combustion to the stack. This entire volume may be referred to as a boiler-furnace enclosure. A dangerous combustible mixture within the boiler-furnace enclosure consists of the accumulation of a quantity of fuel mixed with air in proportions which will result in uncontrolled combustion when an ignition source is supplied. A furnace explosion will result from ignition of this accumulation if the quantity of combustible mixture and the proportion of air to fuel are within the explosive limit of the fuel involved. The magnitude and intensity of the explosion will depend upon both the quantity of combustibles which have accumulated and the proportion of air which is mixed therewith at the moment of ignition.

Numerous situations can arise in connection with the operation of a boiler-furnace which will produce explosive conditions. The most common experiences are:

1. An interruption of the fuel or air supply to the burners, sufficient to result in loss of flame, followed by restoration of supply and delayed ignition.

2. The accumulation of an explosive mixture of fuel and air as a result of loss of flame at one or more burners in the presence of other burners operating normally or during lighting of additional burners.

3. The accumulation of an explosive mixture of fuel and air as a result of fuel leaking into the furnace prior to startup, or after a complete furnace flame-out and the subsequent ignition of the accumulation by a spark or other ignition source, such as attempting to light or relight burners.

4. Unstable or rich flame and subsequent dilution of unburned fuel accumulation resulting in a flammable fuel-air mixture with delayed ignition.

5. Accumulation of pyrolysis gases.

The conditions favorable to a boiler-furnace explosion described above are typical examples. Improved instrumentation and protective devices, proper operating sequence, and a clear understanding of the problem by both designers and operators can greatly reduce the risk and actual incidence of furnace explosions.

The interlock systems should be designed and arranged so that the necessary testing and checking can be easily accomplished in a logical manner. All equipment should also be selected with testing and checking in mind and the equipment should be installed and arranged so that this can be done easily and efficiently.

Prior to the initial start-up or start-up after a boiler planned annual type outage, the auxiliary fuel burning equipment and burner management system should be thoroughly tested and checked. This testing and checking should include the settings of all interlocks and prove operations of each system.

The idle auxiliary fuel system on recovery boilers having two auxiliary fuel systems should be thoroughly tested and checked before making a changeover to the idle system.

After the initial start-up of the recovery boiler or start-up after a planned annual type outage, the auxiliary fuel burning equipment and its associated burner management system should be periodically tested and checked at proper intervals.

A record of testing and checking should be maintained on a form similar to that shown in Figure 1.

1.2 Preventive Maintenance Program

The burner management systems for recovery boilers are only as good and only as reliable as the preventive maintenance they receive.

It is recommended that the maintenance program follow the AF&PA ***Maintenanc***e, Volume 2, as prepared by the Subcommittee on Operator Training and Proper Maintenance of Recovery Units and Associated Equipment of the Black Liquor Recovery Boiler Advisory Committee.

The assistance of the boiler and supporting equipment manufacturers can be invaluable with reference to a proper preventive maintenance program and should be solicited.

1.3 Testing and Checking Program

It is essential that the burner management system for a recovery boiler be maintained in proper operating condition. The only way this can be accomplished is through a program of testing and checking.

A formal written testing and checking program should be set up. It should cover all equipment and all interlocks. The testing and checking should be frequent enough so that inoperative equipment or malfunctions will not go undetected for any period of time. The testing and checking should be at regular intervals and for no piece of equipment or interlock should this interval exceed twelve months. Much of the equipment and many of the interlocks may require testing and checking daily, weekly, biweekly, or monthly. The testing and checking program which is set up should be rigidly adhered to and faithfully followed.

Any malfunctions or inoperable equipment that are discovered during normal operations or during test and checking should be immediately corrected.

The testing and checking program should cover the setting of each interlock and the functional operation of each system.

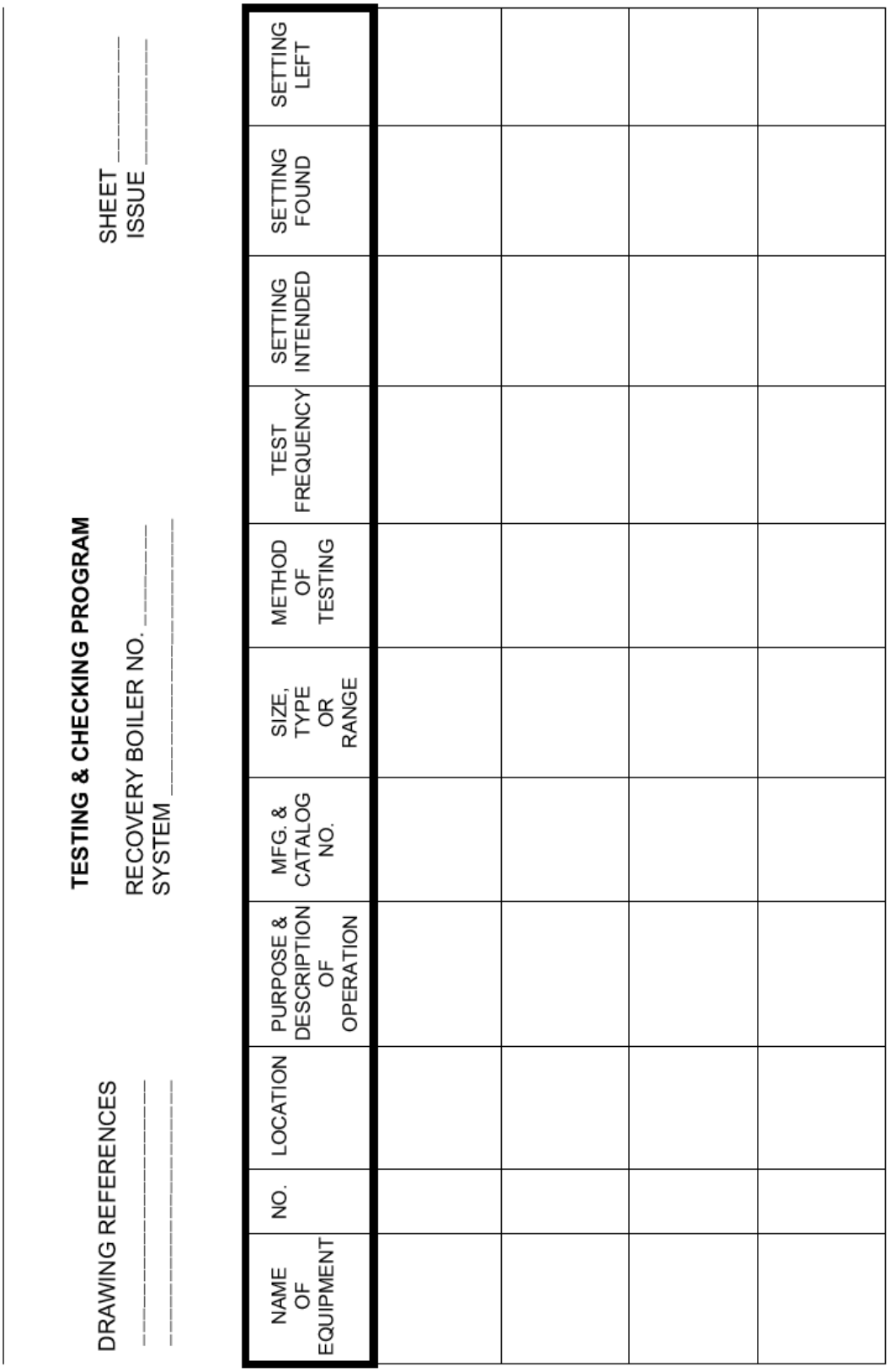

FIGURE 1 - TEST & CHECKING RECORD FORM

Fig. 1. Test and Checking Record Form

CHAPTER 2 DEFINITIONS

Atomizing Medium: A supplementary fluid, such as steam or air, applied to an oil burner to assist the atomization of oil, through a nozzle into a furnace in a finely divided state.

Atomizing Medium Interlock: A differential pressure sensing device to close oil burner BSSV(s) when the differential pressure between the atomizing medium and oil is not within predetermined limits for safe firing. Some systems use a simple pressure switch in the atomizing medium line to each burner. The switch is interlocked with the oil shutoff valve. Other systems require satisfying a pressure differential between the oil and the atomizing medium. Unless the burner is designed to tolerate having the pressure of the atomizing means lower than the oil pressure, the latter is preferred.

Auxiliary Fuel: Fuel gases or fuel oils which are required to initiate recovery boiler firing and may be used to supplement or stabilize black liquor firing. Waste streams are not auxiliary fuels.

Auxiliary Fuel Safety Shutoff Valve: A valve which automatically and completely shuts off the flow of auxiliary fuel to a burner, group of burners or igniters.

Burner Header Safety Shutoff Valve (BHSSV): A safety shutoff valve in the supply header to hearth burners or upper level burners.

Burner Safety Shutoff Valve (BSSV): A safety shutoff valve in the fuel supply line to each burner.

Igniter Header Safety Shutoff Valve (IHSSV): A safety shutoff valve in the igniter fuel header supplying an auxiliary fuel to a system of igniters of a recovery boiler.

Igniter Safety Shutoff Valve (ISSV): A safety shutoff valve in the supply line to each igniter.

Main Header Safety Shutoff Valve (MHSSV): A safety shutoff valve in the auxiliary fuel supply piping supplying fuel to a complete system of burners and igniters of a recovery boiler.

Recirculation Safety Shutoff Valve (RSSV): A safety shutoff valve in a fuel oil recirculation line, which permits circulation of oil from the recovery boiler to the oil supply source and heater. This valve prevents back flow of oil from the supply source to the boiler.

Burner: A device for the introduction of auxiliary fuel and air into the recovery furnace in a pattern to establish ignition and maintain stable combustion.

Hearth or Start-up Burner: A burner located below the liquor guns used to establish suitable conditions to initiate firing of black liquor and may be used to stabilize combustion of black liquor.

Upper Level or Load Burner: A burner located above the liquor gun port elevation provided to supplement steam generation.

Burner Air Flow Interlock: System that senses (direct or inferred) combustion air flow to each burner and interrupts auxiliary fuel flow at a predetermined minimum safe air flow.

Burner Management System (BMS): The auxiliary fuel burner control system designed to assure safe operation of auxiliary burners. The system requires the operator to follow a predetermined sequence to initiate firing, provides system status information to the operator and permits operator intervention. The burner management system includes the auxiliary fuel interlock system, fuel trip system, master fuel trip system, flame monitoring and tripping systems, ignition subsystem, and main burner subsystem.

Combustion Control System: System to regulate the furnace fuel and air inputs for both auxiliary fuel (including NCG streams and other liquid waste streams) and black liquor and maintain air/fuel ratio within the limits required for safe combustion throughout the operating range of the recovery furnace.

Emergency Shutdown Procedure (ESP) System: The ESP system permits immediate termination of all fuel firing, rapid draining and depressurization of the boiler if water is suspected to be entering the recovery furnace. Refer to the BLRBAC *Emergency Shutdown Procedure (ESP) and Procedure for Testing ESP System for Black Liquor Recovery Boilers* for further information.

ESP Interlock: Interlock that interrupts all fuel firing (closes auxiliary fuel safety shutoff valves and diverts black liquor) and prevents firing of auxiliary fuel until interlock is manually reset by the operator.

Direct Contact Evaporator Outlet Temperature Interlock: System that monitors direct contact evaporator outlet temperature, alarm at 100 F above operating temperature and interrupts all fuel firing at 200 F above operating temperature. Also terminates combustion air flow on trip and may actuate a fire extinguishing system. See BLRBAC *Fire Protection in Direct Contact Evaporators and Associated Equipment* for further description.

Flame Supervisory System: Portion of the BMS that functions to shutoff fuel to a burner and igniter upon detecting loss of either igniter or burner flame.

Furnace: That part of a boiler in which combustion of fuel(s) takes place. The primary function of the recovery boiler furnace is the combustion of black liquor and the chemical conversion of sodium sulfate to sodium sulfide, which can be regenerated and reused in

the pulping process. Burning of auxiliary fuel is essential to raise the furnace temperature to safely initiate combustion of the black liquor.

Furnace High Pressure Interlock: System to sense excessive high pressure in the furnace that may damage the boiler. High pressure may result from boiler tube rupture, loss of induced draft fan, or other operational upsets. All fuel firing is terminated and forced draft fans are stopped.

Furnace Low Pressure Interlock: System to sense excessive low pressure in the furnace that may damage the boiler. Low pressure may result from loss of forced draft fans. All fuel firing is terminated and all fans are stopped.

Hearth Zone: Portion of the furnace from the liquor gun port elevation down to the furnace floor.

High/Low Gas Pressure Interlock: A system that interrupts fuel gas flow to the recovery furnace if pressure is outside of the predetermined safe firing pressure.

High/Low Oil Pressure Interlock: A system that interrupts fuel oil flow to the recovery furnace if pressure is outside of the predetermined safe firing pressure.

Igniter: A device providing sufficient energy to immediately ignite an auxiliary fuel burner. An igniter may be gas or oil fired or may be an electric device to directly ignite an auxiliary fuel burner.

- **Continuous Gas or Light Oil Fueled Igniter**: A spark ignited supervised burner supplying sufficient energy to ignite and maintain ignition of an associated auxiliary fuel burner under all light off and firing conditions. Location and capacity of the igniter assures minimum ignition temperature for any combustible combination of burner fuel and air inputs.

- **Interrupted Gas or Light Oil Fueled Igniter**: A spark ignited supervised burner used to ignite an associated auxiliary fuel burner under prescribed light-off conditions. Interrupted igniters may be shutdown at the end of the main burner trial for ignition period or may be left in service to support combustion of the main burner fuel under controlled firing conditions. When left in service beyond the main burner trial for ignition, interrupted igniters are either sized as continuous igniters or are provided with separate igniter and main burner flame supervision. When not sized as a continuous igniter, loss of main burner flame after the trial for ignition period, causes the shutdown of the burner and igniter fuels.

- **Interrupted Direct Electric Igniter** - A retractable igniter providing a high energy electrical spark discharge or high energy electric arc capable of directly igniting the auxiliary fuel burner. (Interrupted service only.) Supervision of main burner flame is required.

Supervise: Sense an unsafe firing condition and automatically initiate corrective action.

30% Minimum Airflow: Purge air flow equal to 30% of the total combustion air flow required for black liquor firing at maximum continuous rating (MCR).

Trial for Ignition: Time interval during which the burner flame safeguard system permits the BSSV to be open without proof that burner flame has been established (generally limited to 10 seconds for gas and 15 seconds for oil).

Vent Valve: Automatic valve on vent line off of gas supply pipe between two auxiliary fuel safety shutoff valves. Vent valve is interlocked to open when safety shutoff valves close to prevent build-up of pressure against the second (downstream) shutoff valve should the first (upstream) shutoff valve leak. This reduces chance of gas leakage into the recovery furnace when the safety shutoff valves are closed.

CHAPTER 3 AUXILIARY FUEL SAFE FIRING SYSTEM REQUIREMENTS

The fuel burning system includes the fans, air ducts, dampers, air heaters, piping, vents, burners, fuel nozzles, igniters, furnace, flues, and stack. This system, and any other equipment incorporated into this system in which air to the burners or the products of combustion from the burners must pass to safely satisfy functional requirements and not interfere with the combustion process, should be properly sized and interconnected.

The fuel burning system should be sized to fit the boiler, should be compatible with other parts of the boiler system and should be capable of being controlled over the full operating range of the system.

The fuel burning system design should be based on the following fundamentals:

3.1 Air supply

- The air supply equipment should be properly sized and arranged to ensure a continuous, steady airflow adequate for all operating conditions of the system.

- The arrangement of ductwork, fan inlets, and air heaters should minimize the contamination of the air supply from atmospheric precipitation, steam or condensate (steam to combustion air heat exchanger), boiler water (feedwater to combustion air heat exchanger) or low oxygen content gases exhausted from this or other nearby processes. Suitable drain openings should be provided.

3.2 Auxiliary Fuel Supply

- The auxiliary fuel supply equipment should be sized and arranged to ensure a continuous, steady flow of fuel adequate for all operating conditions of the system.

- The fuel supply equipment should be designed and installed to prevent contamination of the fuel. Appropriate access to important fuel system components should be provided. Drain opening should be provided at low points in the piping.

- The fuel supply equipment should be designed with careful consideration of the operating environment and ambient conditions. The system should be able to withstand high temperatures without failure in order to reduce its vulnerability to external fires.

- Positive means to prevent leakage of auxiliary fuel into an idle furnace should be provided. Provisions should be included to vent gas piping upstream of the last shutoff valve in any line to a burner or igniter. Terminate vents at a safe outdoor location.

- Provisions should be made in gas piping to permit testing for leakage and repair. This should include providing a permanent and ready means for making easy, accurate, periodic tightness test of safety shutoff valves in the auxiliary fuel system.

3.3 Ignition System

- The ignition system should be sized and arranged to positively and smoothly ignite the auxiliary fuel.

- Each igniter should be provided with an integrally mounted ignition source utilizing a spark or similar device that is automatically energized with the admission of fuel to the igniters.

- Flame supervision should be provided for all fuel fired igniters.

- The igniter and its control equipment should be designed for the environment with convenient access for maintenance.

3.4 Interrupted Igniters

The logic diagrams assume the use of continuous gas or oil fired igniters (igniters that remain lit while the main burner is firing). Interrupted igniters (igniters that are shut down when the main burner is firing) are sometime used when the igniter burns different fuel than the main burner. In this case, the following also apply:

- The igniter flame and the main burner flame must be monitored, either independently or by a common monitor.

- The flame monitor must be able to distinguish flame from the liquor/bed background radiation.

- The igniter flame must be proven before fuel is admitted to the main burner.

- The main burner flame must be proven after the igniter is turned off.

3.5 Auxiliary Fuel Burner System

- The burner system should be arranged to produce a heat pattern that will satisfy the special requirements of the auxiliary fuel system on a black liquor recovery boiler.

- The minimum safe fuel oil temperature should be interlocked.

- Retractable igniter position should be interlocked.

- The range of suitable burner operation should be verified for each burner producing a separate flame envelope at recovery boiler startup. This check should be made from

minimum possible firing rate through maximum possible firing rate. The burner management system limits should be adjusted to trip at upper and lower limits of the safe firing conditions.

- Only burner equipment and controls suitable for the recovery boiler environment should be utilized. This equipment should be arranged for convenient maintenance access.

3.6 Flame Supervision

- The burner or igniter flame supervisory system should initiate closure of the burner and igniter safety shutoff valves within four seconds of detecting flame failure.

- The flame supervisory system equipment should be suitable for the recovery boiler environment.

- No flame supervisory system device should be bypassed when the burner it serves is operating.

- Tests of the dependability of the flame sensing device should be made at installation and at regular intervals thereafter by manually shutting off the fuel to the supervised flame or otherwise simulating flame failure and noting response of the flame supervisory system. A burner should not be operated with burner or igniter flame supervision that is not functional.

3.7 Furnace

- The furnace should not be equipped with auxiliary fuel burning capacity which, when firing auxiliary fuel only, can exceed the steam generating design limit of the boiler.

- The auxiliary fuel combustion control system should be coordinated (manually or automatically) with the black liquor fuel combustion system and any waste fuel combustion system to prevent firing in excess of the boiler maximum design rating.

- The furnace should be designed to withstand the maximum negative pressure that can be developed by the induced draft fan(s) or a low furnace pressure interlock should be provided.

- A high furnace pressure trip, set at no more than 80% of the furnace static design pressure, should be provided (see FURNACE PRESSURE TRIP, Chapter 6).

- Adequate, properly placed observation ports should be provided to permit inspection of each flame envelope relative to its associated burner.

3.8 Removal System for Gaseous Products of Combustion

The gas flues, fan, stack and any other equipment through which the flue gas passes should be sized and arranged so that all products of combustion can be removed continuously during all operating conditions of the boiler.

3.9 Electrical

- Only electrical equipment suitable for the severe conditions of the recovery boiler environment should be utilized. Electrical system design should take into consideration exposure to elevated temperatures, corrosive fumes, water or moisture, vibration, the weather, fuel oil, black liquor and damage by fire and explosion.

- The design of the electrical installation should also take into consideration proper power supplies for the various systems and the logical arrangement of all interlocks for ease of understanding, maintenance and troubleshooting.

- Enclosures should be designed to protect equipment from corrosive fumes, water and moisture, black liquor, fuel oil or other contaminants.

- Any electrical equipment mounted on or near the boiler should be thermally insulated from boiler heat. For wiring that cannot be thermally insulated from the boiler or where the ambient temperature at the boiler exceeds normal wire ambient temperature rating, high temperature wiring should be used. The electrical equipment should either be located where water, fuel oil, black liquor, etc. will not fall on or over the equipment or the equipment should be suitably shielded or covered.

- Electrical equipment and wiring should be located where it will receive minimum damage in the event of a fire or explosion.

- The burner management system should be arranged to trip all fuel (auxiliary fuel, black liquor fuel and NCG's) to the boiler upon loss of electrical power. The auxiliary fuel safety shutoff valves should close automatically upon loss of electrical power.

- Electrical power to the burner management system should be from a reliable, independently protected circuit. No other boiler controls, alarms or instrumentation should be on this circuit. Failure of the burner management system or power supply to the system should not affect other boiler instrumentation or controls. Each burner control circuit should be individually protected so that an electrical failure in the wiring of one burner will not result in deenergization of the entire burner management system and boiler shutdown.

3.10 Fuel Piping

- Only piping materials compatible with the auxiliary fuel and suitable for the black liquor recovery boiler environment should be utilized. The piping should be designed in accordance with applicable codes.

- All piping and equipment should be located to minimize damage from mechanical damage, fire, explosion and corrosion. The IHSSV's, MHSSV's and RSSV's should be supported independent from the boiler casing.

- Auxiliary fuel shutoff valves (manual or automatic) should be provided outside the mill determined explosion risk boundary so the auxiliary fuel supply can be shut off if mechanical breakage, fire or explosion occurs.

3.11 Quality of Equipment

The reliability and the dependability of the auxiliary fuel burning system is determined by proper system design and selection of known reliable components. All equipment and components should be suitable for the severe environmental condition in a recovery boiler area. In some cases, this may require construction of special housings to adequately protect system components. Use equipment listed or approved by a nationally recognized testing laboratory.

CHAPTER 4 SYSTEMS

An interlock system that will protect operating personnel from hazards and equipment from damage while maximizing boiler availability should be provided. The purpose of the interlock system is to ensure boiler operations follow a safe, pre-established sequence. Interlocks should prohibit improper actions during startup and operation with auxiliary fuel by initiating trip devices when an unsafe operating condition is detected.

Remote light off of auxiliary fuel burners is not recommended for black liquor recovery boilers. The following is recommended for auxiliary fuel burner light off:

4.1 Purge of Recovery Boiler

- A purge should be completed on any auxiliary fuel start or on any restart which follows loss of purge credit.

- The purge should be at 30% minimum air flow or greater air flow (see definitions).

- Purge air flow should be maintained for at least five minutes and until satisfactory level of oxygen is indicated by furnace instrumentation. If carbon monoxide or combustibles instrumentation is provided, verify level is satisfactory.

- All purge air should be introduced below liquor gun ports.

- All air heaters and ducts should be purged during the furnace purge cycle. Direct fired air heaters should not be fired during the purge cycle.

- The highest practical purge air flow rate above the established minimum (30% MCR) should be provided. Some combinations of smelt bed and purge air flow rate may result in smelt flow exceeding shatter spray and dissolving tank capacity. The safe highest purge air flow rate for the particular boiler should be determined and used. When no smelt bed present, the maximum combustion air flow rate available should be used.

- An oxygen analyzer should be provided. Provision of a combustibles or a carbon monoxide analyzer is suggested. If level of oxygen is lower or level of combustibles is higher than typical (satisfactory) at the end of the purge period, the purge should be extended until levels are satisfactory.

4.2 Manual Trip Provisions

Manual fuel trip button(s), one for black liquor and one for auxiliary fuel or one for both black liquor and auxiliary fuel, should be provided in the control room to allow for initiation of a master fuel trip.

Manual auxiliary fuel trip buttons should be provided in the control room and at each burner level, to permit shutdown of the auxiliary fuel system.

4.3 Auxiliary Fuel Safety Shutoff Valve

Manual reset only safety shutoff valves (for MHSSV, IHSSV, BHSSV, BSSV and RSSV) should be provided to assure correction of a fault that causes a trip. Trip with manual reset only can be accomplished mechanically or electrically. An audible and visual alarm that is activated when one of these safety shutoff valves is not proven closed within five seconds of being tripped should also be provided (proof of closure).

4.4 Bypassing Interlocks

The burner management system should be designed so no interlock can be by passed or otherwise defeated by means of a hardwired switch. In order to provide for orderly maintenance of the burner management system, it may be necessary at times to temporarily install jumpers on individual devices. This should only be done with the approval of the Recovery Superintendent, or the designee. Control of this process should be established by an administrative system (Jumper Log) that identifies when the jumper was installed and when it was removed. The use of a jumper should be considered an emergency condition and repairs should be initiated immediately. This program should be the same for either hardwired jumpers or software forced conditions.

4.5 Interlock System - Sequence Logic

An interlock system that follows the sequence and protection indicated in the permissive starting logic, protective tripping logic and piping diagrams should be provided:

Common Permissive Starting and Protective Tripping Logics – Figures 2, 3.

Gas Igniter with Gas Burners - Figures 4, 5, 6, 7, 8, and 9.

Gas Igniters with Oil Burners - Figures 10, 11, 12, 13, 14, 15, and 16.

Oil Igniters with Oil Burners - Figures 12, 13, 14, 17, 18, 19, and 20.

Direct Electric Igniters - Figures 12, 13, 14, 21, and 22.

Note: *Combination Fuel Burner Systems. For burner systems firing both gas and oil, combine the recommended logic and piping diagrams for individual gas and oil systems. Items common to the firing of both fuels, such as fan and purge interlocks, need not be duplicated. In principal, the system should provide at least the recommended safety protection for each fuel as if it were the only fuel used. Do not*

fire two fuels simultaneously in a single burner. For dual auxiliary fuel boilers, arrange the tripping logic so that both fuels are tripped if purge credit is lost.

The **Starting Logic** diagrams graphically show the sequence of operations required to safely place the auxiliary fuel system in operation. In reading these diagrams, all items leading into an "AND" block must be in service and/or within proper limits before any subsequent operation leading out of and following the "AND" block can be performed.

The **Tripping Logic** diagrams show graphically the malfunction or misoperation that will trip equipment out of service. In reading these diagrams, any malfunction or misoperation leading into an "OR" block automatically shuts down everything following the "OR" block.

The **Schematic Piping** diagrams show the various valves and other components in the piping that are mentioned in the Starting and Tripping diagrams. For clarity, miscellaneous piping components normally provided have not been shown. No valve or similar shutoff should be installed in the sensing line to any interlock device, such as a pressure or temperature switch, that could defeat the interlock function if accidentally closed. In a limited number of cases, it could be considered safer to install an isolation valve to allow repair(s) to be performed on interlock device(s) promptly. This could minimize the amount of time the safety interlock will be out of service in cases where an outage would have to be scheduled to make repairs. Isolation valves shall be allowed in these cases only. Examples could be drum level probe columns, black liquor pressure switches, auxiliary fuel system pressure switches, etc. If valves are installed, they must be utilized in a "managed system".

Whenever a "managed system" is utilized on sensing line isolation valves and it is necessary to defeat an interlock by closing a safety interlock sensing line isolation valve, the jumper policy must be followed.

Prior to placing a unit/system in service, a checklist of all the safety interlocks with valves in the sensing lines shall be completed by the operator, documenting that the valves are in the open position and secured per the "management system".

The items and functions listed on the logic diagrams are tabulated and explained, with suggested limits where applicable, in the Logic Explanation Charts following each set of diagrams.

4.6 Scavenging Oil Burners

- Following a fuel trip, oil burners should not be scavenged into the furnace.

- After a normal burner shutdown, the oil gun may be scavenged into the furnace only if the burner igniter is operating.

4.7 Interrelated Recommendations

The following interlock functions are further described in other *Recommended Practice*s. These interlocks are shown on the logic diagrams to illustrate the relationship of other protection systems to the firing of auxiliary fuel.

- EVAPORATOR AND PRECIPITATOR OUTLET TEMPERATURE

  Under certain conditions, it is desirable either to prevent recovery boiler start up or to initiate boiler shutdown upon high evaporator outlet or high precipitator outlet temperature. (See *Recommended Good Practice, Fire Protection In Direct Contact Evaporators And Associated Equipment.*)

- EMERGENCY SHUTDOWN PROCEDURE (ESP) INTERLOCK

  The Emergency Shutdown Procedure interlock prevents recovery boiler startup or initiates shutdown while the boiler is undergoing an ESP. (See *Recommended Emergency Shutdown Procedure For Black Liquor Recovery Boiler*s.)

- BLACK LIQUOR TRIP

  Under certain conditions it is desirable to shut off flow of liquor to the furnace. This may be accomplished by an automatically operated liquor divert system. (See *Safe Firing Of Black Liquor In Black Liquor Recovery Boiler*s.)

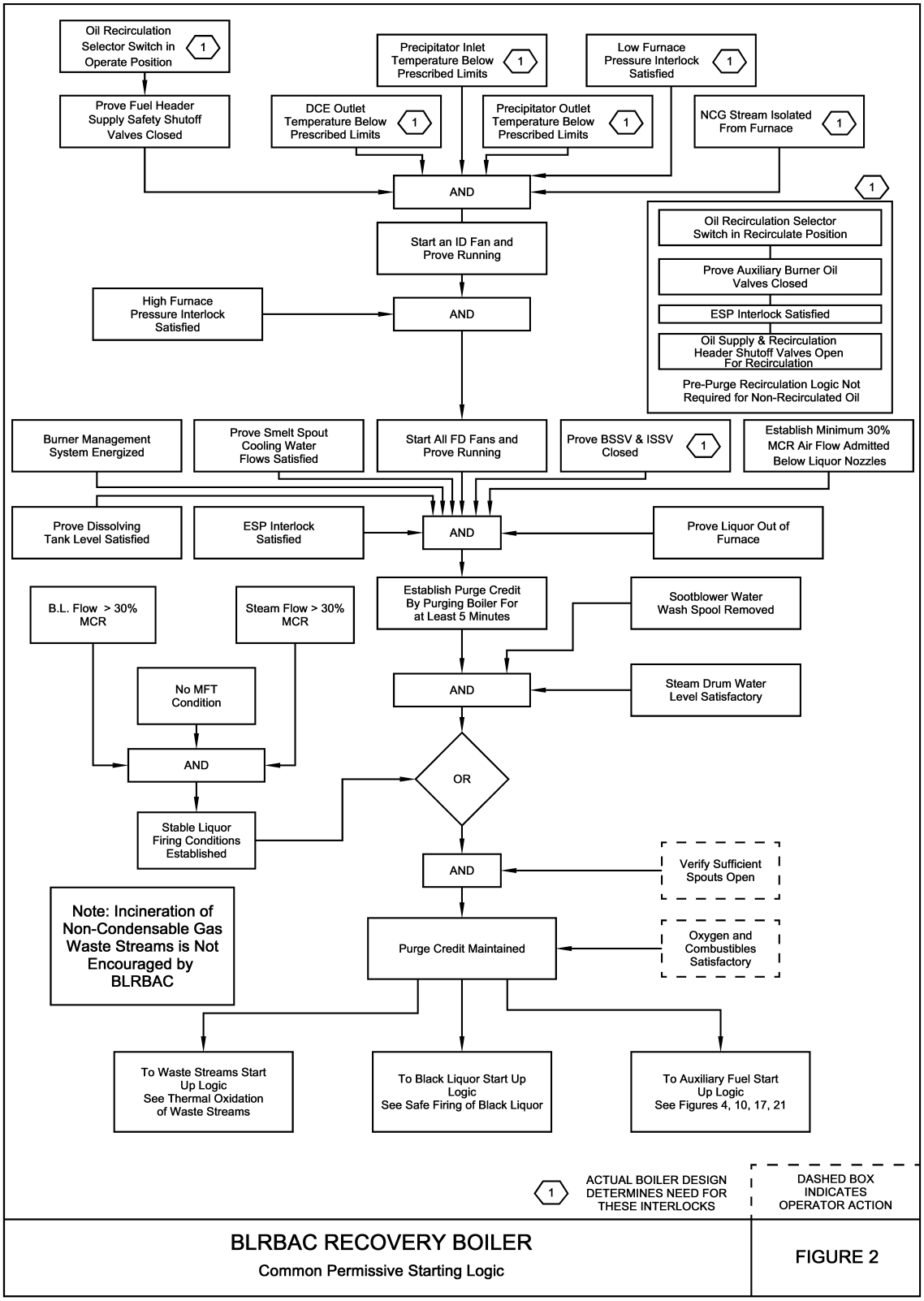

Fig. 2. Common Permissive Starting Logic.

Table 1. Logic Explanation Chart for Figure 2 – Common Permissive Starting Logic

Refer to Figure 2 Logic Explanation Chart Common Permissive Starting Logic		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Oil Recirculation Selector Switch In "Operate" Position	Prevent circulation of oil around boiler during furnace purge.	Possible leakage of oil into furnace during furnace purge.
Prove Fuel Header Supply Safety Shutoff Valves Closed	Prevent start-up if any auxiliary fuel safety shut-off valve is not closed.	Possible explosion during start-up from fuel leaking into idle furnace.
DCE Outlet Temperature Below Prescribed Limits	Prevent start-up of boiler if temperature is 200°F or more above design temperature at rated capacity.	Fire in direct contact evaporator system.
Precipitator Outlet Temperature Below Prescribed Limits	Prevent start-up of boiler if temperature is 200°F or more above design temperature at rated capacity.	Fire in precipitator with direct contact evaporator system.
Precipitator Inlet Temperature Below Prescribed Limits	Prevent start-up of boiler if temperature is 200°F or more above design temperature at rated capacity.	Fire in precipitator with direct contact evaporator system.
Low Furnace Pressure Interlock Satisfied	Detect abnormally low furnace pressure. Set at a minimum of 80% of furnace design pressure (negative).	Possible structural damage from implosion.
NCG Stream Isolated From Furnace	Prevent start-up of boiler if noncondensibles are entering furnace.	Possible explosion from ignition of noncondensible gases.
Start An I.D. Fan And Prove Running	Prove at least one induced draft fan operation for purge and flue gas removal functions.	Potential explosion from improper purge.
High Furnace Pressure Interlock Satisfied	Detect abnormally high furnace pressure. Set at a maximum of 80% of furnace design pressure (positive).	Possible structural damage from high pressure.
Start All F.D. Fans And Prove Running	Prove all forced draft fans operating for purge and air supply functions to purge all ducts and windboxes.	Potential explosion from improper purge or impaired air supplies.
Burner Management System Energized	Provide power to burner safety control circuits.	
Prove BSSV & ISSV Closed	Ensure individual burner valves closed before opening main trip valve.	Possible explosion from fuel entering furnace before controlled sequential burner light-off.
Establish Minimum 30%. MCR Air Flow Admitted Below Liquor Nozzles	Sufficient air for purge requirements, a minimum of 30% of black liquor MCR air flow.	Possible explosion from improper purge, which failed to clear furnace of combustibles.
ESP Interlock Satisfied	Prevent start-up if Emergency Shutdown Procedure interlock has not been reset.	
Prove Dissolving Tank Level Satisfied	Prevent accumulation of undissolved smelt in dissolving tank.	Possible explosion in dissolving tank.
Prove Smelt Spout Cooling Water Flows Satisfied	Ensure proper spout cooling prior to firing auxiliary fuel.	Possible loss of apout and uncontrolled flow of smelt from furnace.
Prove Liquor Out Of Furnace	Prevent start-up if black liquor is entering furnace.	Possible explosion during start-up from pyrolysis gasses.
Establish Purge Credit By Purging Boiler For At Least 5 Minutes	Ensure removal of unburned combustibles from furnace.	Possible explosion from accumulation of combustibles in furnace.
Steam Drum Water Level Satisfactory	Ensure water level correct before light-off.	Damage to pressure parts from firing with improper water level.

Refer to Figure 2 Logic Explanation Chart Common Permissive Starting Logic		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Black Liquor Flow > 30% MCR	Prove combustion of black liquor.	Maintaining purge credit with unstable furnace conditions.
Steam Flow > 30% MCR	Prove combustion of black liquor.	Maintaining purge credit with unstable furnace conditions.
Sootblower Water Wash Spool Removed	Ensure water cannot enter the furnace through the sootblower water wash connection.	Smelt water explosion.
No MFT Condition	Prove all conditions are safe.	Combustion of fuel with unsafe furnace condition.
Stable Black Liquor Firing Conditions Established	Maintain purge credit from black liquor firing.	
Verify sufficient spouts open	Ensure spouts are open to prevent smelt accumulation and allow molten smelt flow from boiler upon start-up.	Protect personnel and equipment from smelt rushes and potential dissolving tank explosions.
Oxygen and Combustibles Satisfactory	Confirm removal of combustibles from furnace.	Potential explosion from ignition of combustible gases.
Purge Credit Maintained	Ensures all interlocks are satisfied.	
Oil Recirculate Selector Switch in Recirculate Position	Permit opening of main oil trip valves for recirculation in a safe manner.	
Prove Auxiliary Burner Oil Valves Closed	Prevent oil from entering furnace during recirculation.	Possible explosion during start-up from auxiliary fuel leaking into furnace.
ESP Interlock Satisfied	Prevent oil recirculation if emergency shutdown procedure interlock has not been reset.	Possible fire from fuel line rupture as a result of a smelt water reaction.
Oil Supply & Recirculatation Header Shutoff Valves Open for Recirculation	Supply oil to header system in safe sequence to ensure adequate oil temperature and viscosity for proper atomization.	

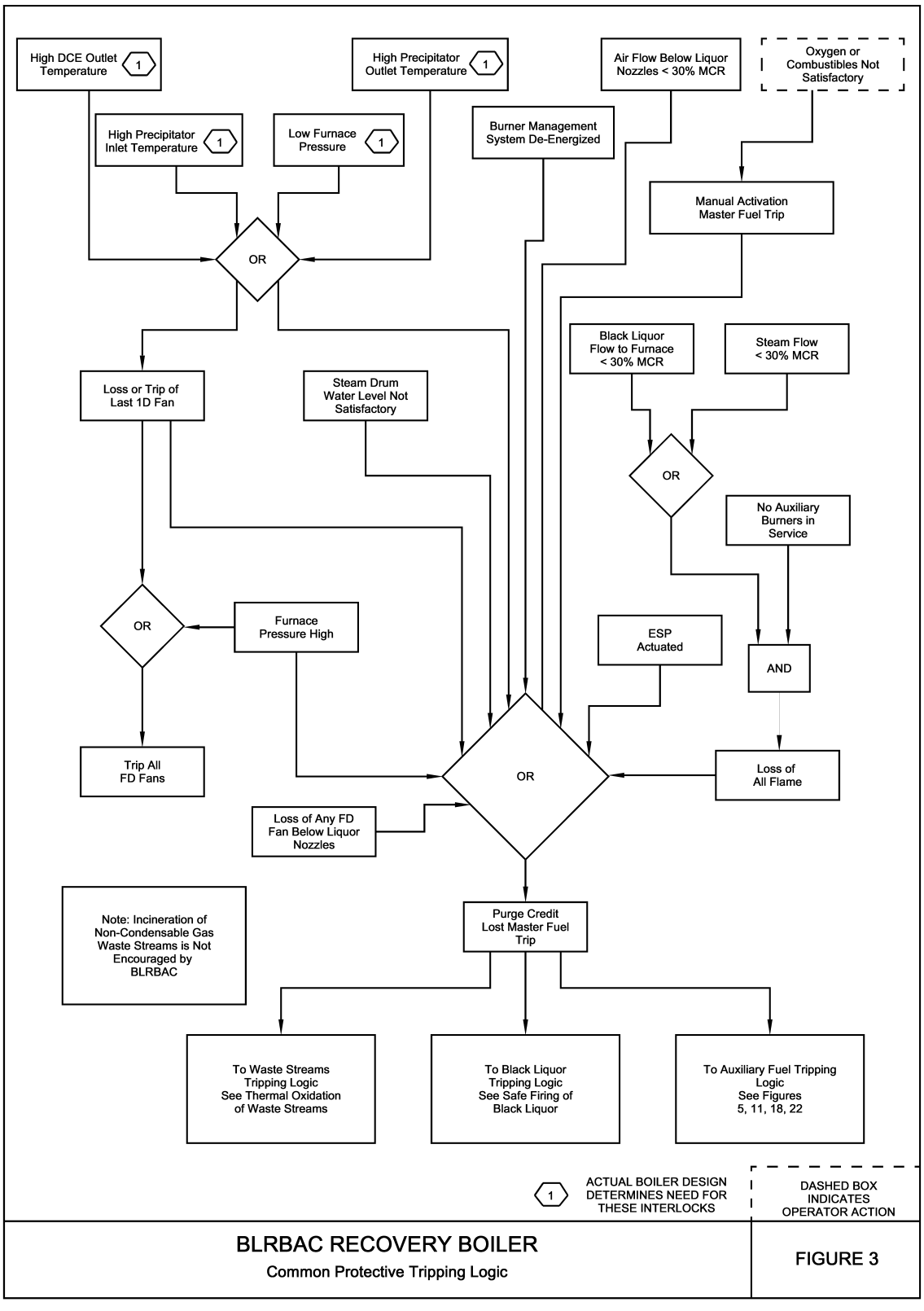

Fig. 3. Common Protective Tripping Logic.

Table 2. Logic Explanation Chart for Figure 3 – Common Protective Tripping Logic

Refer to Figure 3 Logic Explanation Chart Common Protective Tripping Logic		
Logic Diagram Block	**Purpose**	**Hazard Protected**
High DCE Outlet Temperature	Shut down induced draft fan(s), forced draft fan(s) and all fuels at 200°F above design temperature at rated capacity.	Fire in direct contact evaporator.
High Precipitator Outlet Temperature	Shut down induced draft fan(s), forced draft fan(s) and all fuels at 200°F above design temperature at rated capacity.	Fire in precipitator with direct contact evaporator system.
High Precipitator Inlet Temperature	Shut down induced draft fan(s), forced draft fan(s) and all fuels at 200°F above design temperature at rated capacity.	Fire in precipitator with direct contact evaporator system.
Air Flow Below Liquor Nozzles Less Than 30% MCR	Shut off all fuel if airflow below liquor nozzles drops below 30% of MCR black liquor airflow.	Possible explosion from improper fuel-air mixture.
Oxygen or Combustibles Not Satisfactory	Operator terminates all firing when conditions exceed safe operating limits.	Explosion of pyrolysis or unburned fuel gas.
Low Furnace Pressure	Shut down induced draft fan(s), forced draft fan(s) and all fuel.	Possible structural damage from implosion.
Burner Management System De-Energized	Shut off fuel to furnace upon loss of electrical power to burner management control circuits.	Possible explosion during unsupervised firing conditions.
Manual Actuation Master Fuel Trip	Stop firing all fuels.	
Loss or Trip of Last I.D. Fan	Shut off all forced draft fan(s) and all fuels.	Pressuring of furnace creates unsafe firing conditions and fire hazard to personnel and equipment.
Steam Drum Water Level Not Satisfactory	Stop firing all fuels when water level is improper.	Damage to pressure parts from firing with improper water level.
Black Liquor Flow to Furnace < 30% MCR	Remove purge credit for black liquor firing.	Possible explosion from pyrolysis gasses.
Steam Flow < 30% MCR	Remove purge credit for black liquor firing.	Possible explosion from pyrolysis gasses.
Furnace Pressure High	Shut off all forced draft fan(s) and all fuels if a hazardous or unstable draft condition exists or if an explosion occurs.	Pressurizing of furnace creates unsafe firing conditions and fire hazard to personnel and equipment.
ESP Actuated	Shut off all fuel to furnace during ESP.	
No Auxiliary Burners in Service	Require furnace purge prior to ignition after loss of all flame.	Possible explosion due to pyrolysis gasses. Note: Igniters are not to be classified as a burner.
Trip All Fans	Shut down FD fans with loss of ID fans or high furnace pressure.	Prevent possible structural damage.
Loss of any FD Fan Below Liquor Nozzles	Shut off all fuels if any FD fan below the liquor guns trips.	Possible explosion form accumulations of explosive mixtures.
Loss of all Flame	Stop firing all fuel.	Possible explosion from unburned combustibles.
Purge Credit Lost Master Fuel Trip	Shut off all fuels to furnace.	Combustion of fuel with unsafe furnace condition.
Isolate NCG Waste Steams	Stop introduction of NCG into furnace.	Possible explosion.

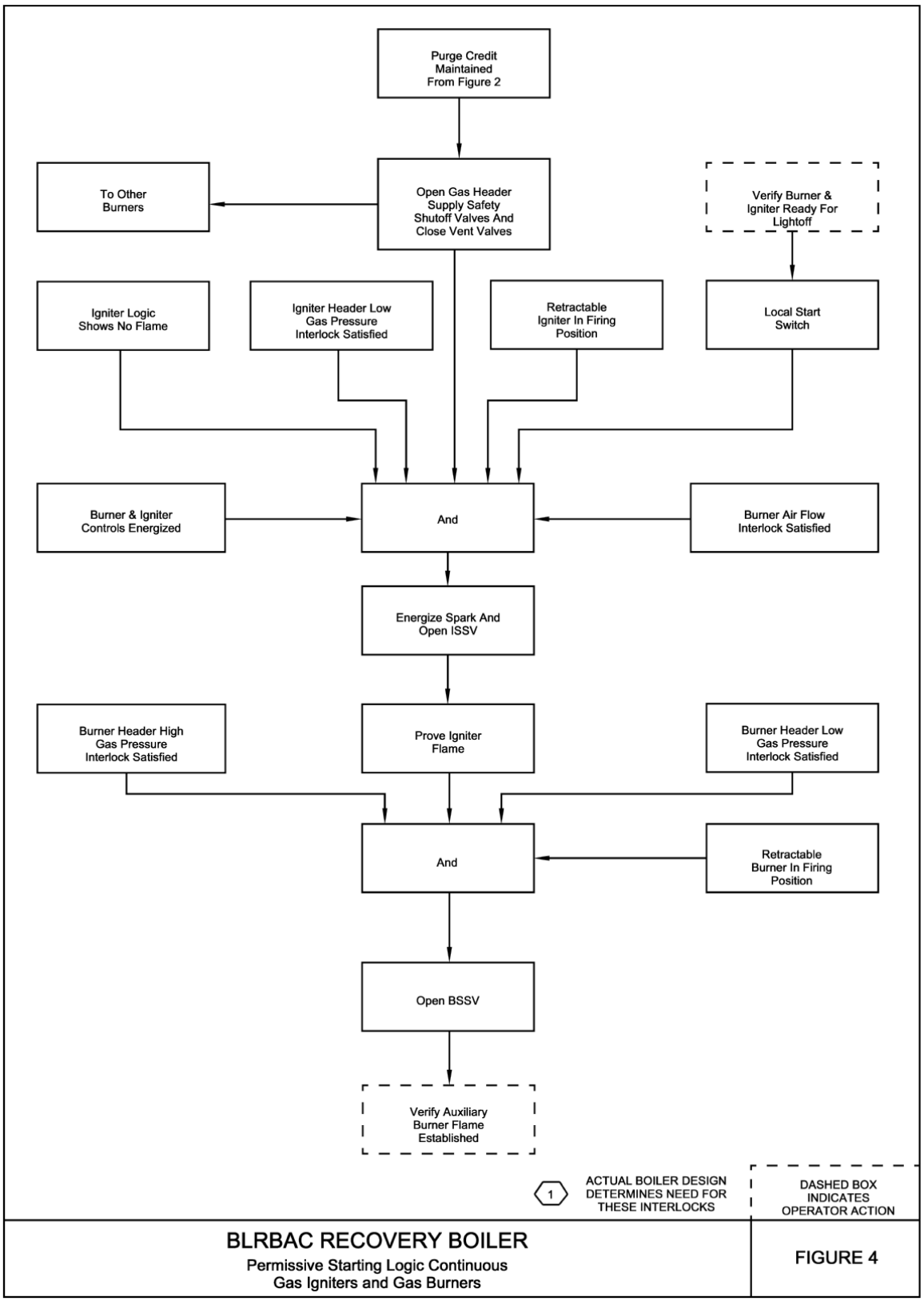

Fig. 4. Permissive Starting Logic Continuous Gas Igniters and Gas Burners.

Table 3. Logic Explanation Chart for Figure 4 – Permissive Starting Logic Continuous Gas Igniters and Gas Burners

Refer to Figure 4 Logic Explanation Chart Permissive Starting Logic Continuous Gas Igniters and Gas Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Purge Credit Maintained	Ensures all interlocks are satisfied.	
Open Gas Header Supply Safety Shut-Off Valves and Close Vent Valves	Supply gas to burner system prior to light-off.	
Igniter Logic Shows No Flame	Prove flame sensor is not falsely indicating flame.	
Igniter Header Low Gas Pressure Interlock Satisfied	Detect abnormally low igniter gas pressure. Set at 75% of required normal supply pressure.	Unstable burner ignition from low igniter heat input.
Retractable Igniter in Firing Position	Ensure correct position for positive burner ignition.	Possible explosion from improper or delayed ignition.
Verify Burner & Igniter Ready for Light-Off	Operator to visually determine burner and igniter systems are ready for start-up and furnace opening is clear.	
Local Start Switch	Ensure only local light-off of burner.	
Burner & Igniter Controls Energized	Provide power to burner and igniter safety control circuit. All safety devices should fail safe on loss of power.	
Burner Air Flow Interlock Satisfied	Ensure airflow through individual burners.	Possible explosion from improper fuel-air mixture.
Energized Spark and Open ISSV	Provide ignition source for main burner is proper sequence.	
Prove Igniter Flame	Prove positive ignition source by a flame-supervising device within 10-second trial period.	Possible explosion if delayed burner ignition.
Burner Header High Gas Pressure Interlock Satisfied	Detect abnormally high gas pressure. Set at or below 125% of full load gas pressure.	Unstable burner conditions.
Burner Header Low Gas Pressure Interlock Satisfied	Detect abnormally low gas pressure. Set at minimum stable burner gas pressure.	Unstable burner conditions.
Retractable Burner in Firing Position	Ensure correct position for proper burner operation.	Possible explosion from improper or delayed ignition.
Open BSSV	Provide gas to burner in proper sequence.	
Verify Auxiliary Burner Flame Established	Operator to visually determine that the burner flame is established.	

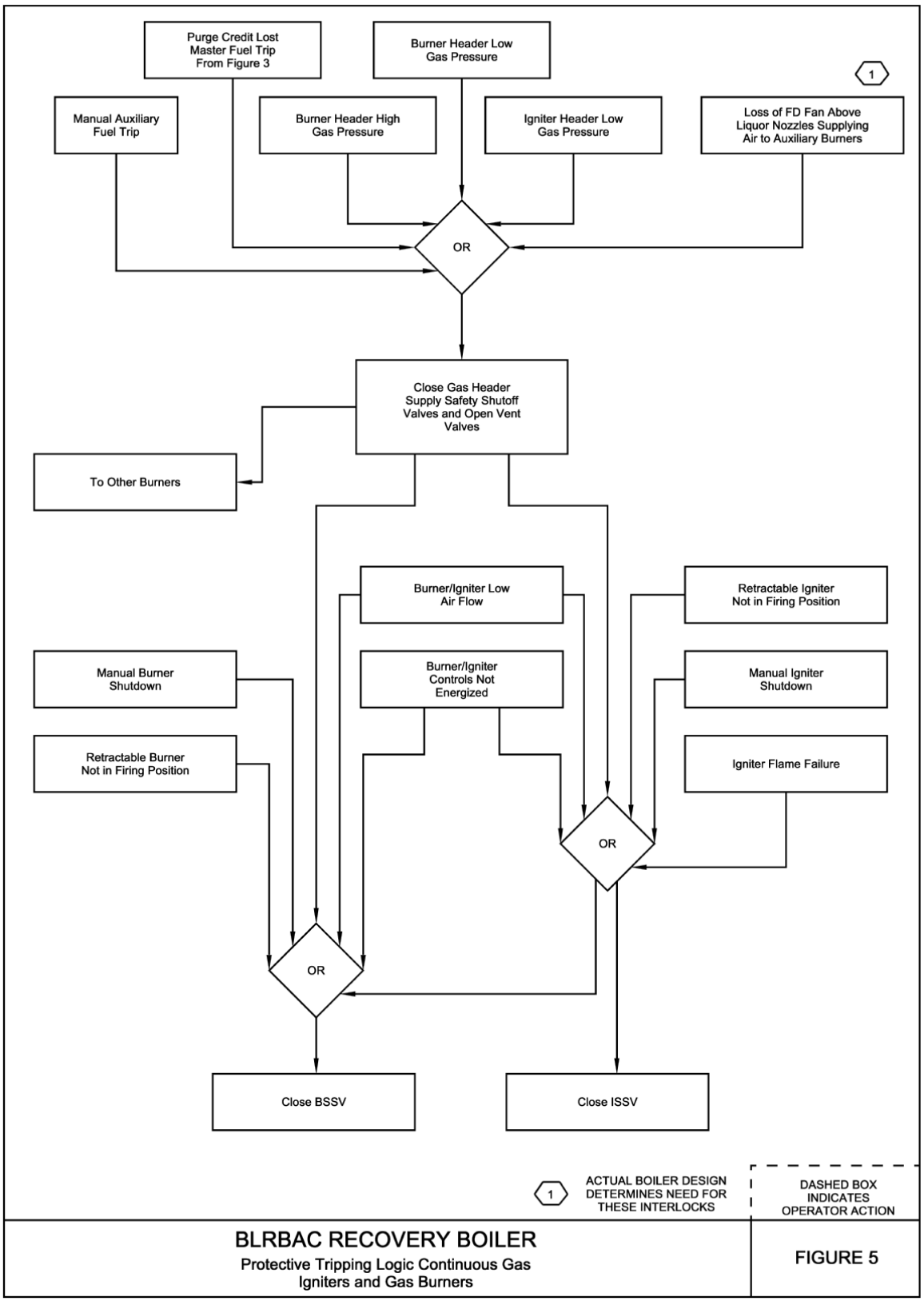

Fig. 5. Protective Tripping Logic Continuous Gas Igniters and Gas Burners.

Table 4. Logic Explanation Chart for Figure 5 – Protective Tripping Logic Continuous Gas Igniters and Gas Burners

Refer to Figure 5 Logic Explanation Chart Protective Tripping Logic Continuous Gas Igniters and Gas Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Purge Credit Lost Master Fuel Trip	Shut off all fuels to furnace.	Combustion of fuel with unsafe furnace condition.
Burner Header Low Gas Pressure	Shut off all gas to appropriate burner gas header if gas pressure drops below minimum stable burner gas pressure.	Unstable burner conditions.
Manual Auxiliary Fuel Trip	A remote manual device to shut off all auxiliary fuel to the furnace.	
Burner Header High Gas Pressure	Shut off appropriate burner gas header if gas pressure exceeds 125% of full load gas pressure.	Unstable burner conditions.
Igniter Header Low Gas Pressure	Shut off appropriate gas headers if gas pressure drops below 75% of normal supply pressure.	Unstable burner conditions from low igniter heat input.
Loss of FD Fan Above Liquor Nozzles Supplying Air To Auxiliary Burners	Shut-off auxiliary fuels associated with FD fan above liquor nozzles.	Possible explosion from accumulations of explosive mixtures.
Close Gas Header Supply Safety Shut-Off Valves and Open Vent Valves	Ensure immediate and positive shutoff of all gas to furnace when required.	Possible explosion from continuing gas flow to furnace during unsafe conditions.
Burner/Igniter Low Air Flow	Shut off gas supply to an igniter and its associated burner on loss of airflow.	Possible explosion from improper combustion.
Burner/Igniter Controls Not Energized	Shut off gas supply to an igniter and its associated burner when power supply is interrupted.	Loss of power supply nullifies safeguards.
Manual Burner Shutdown	Initiate normal shutdown of burner.	
Retractable Burner Not In Firing Position	Shut off gas supply to the burner if burner is moved from its proper firing position.	Fire or explosion from improper location.
Retractable Igniter Not In Firing Position	Shut off gas supply to the igniter if igniter is moved from its proper firing position.	Fire or explosion from improper location.
Manual Igniter Shutdown	Initiate normal shutdown of igniter.	
Igniter Flame Failure	Shut off gas supply to an igniter and its associated burner if the igniter flame fails.	Possible explosion from continuing gas flow to igniter or burner in case of igniter flameout.
Close BSSV	Ensure immediate and positive shutoff of gas supply to a burner when required.	Possible explosion from continuing gas flow to furnace during unsafe conditions.
Close ISSV	Ensure immediate and positive shutoff of gas supply to an igniter when required.	Possible explosion from continuing gas flow to furnace during unsafe conditions.

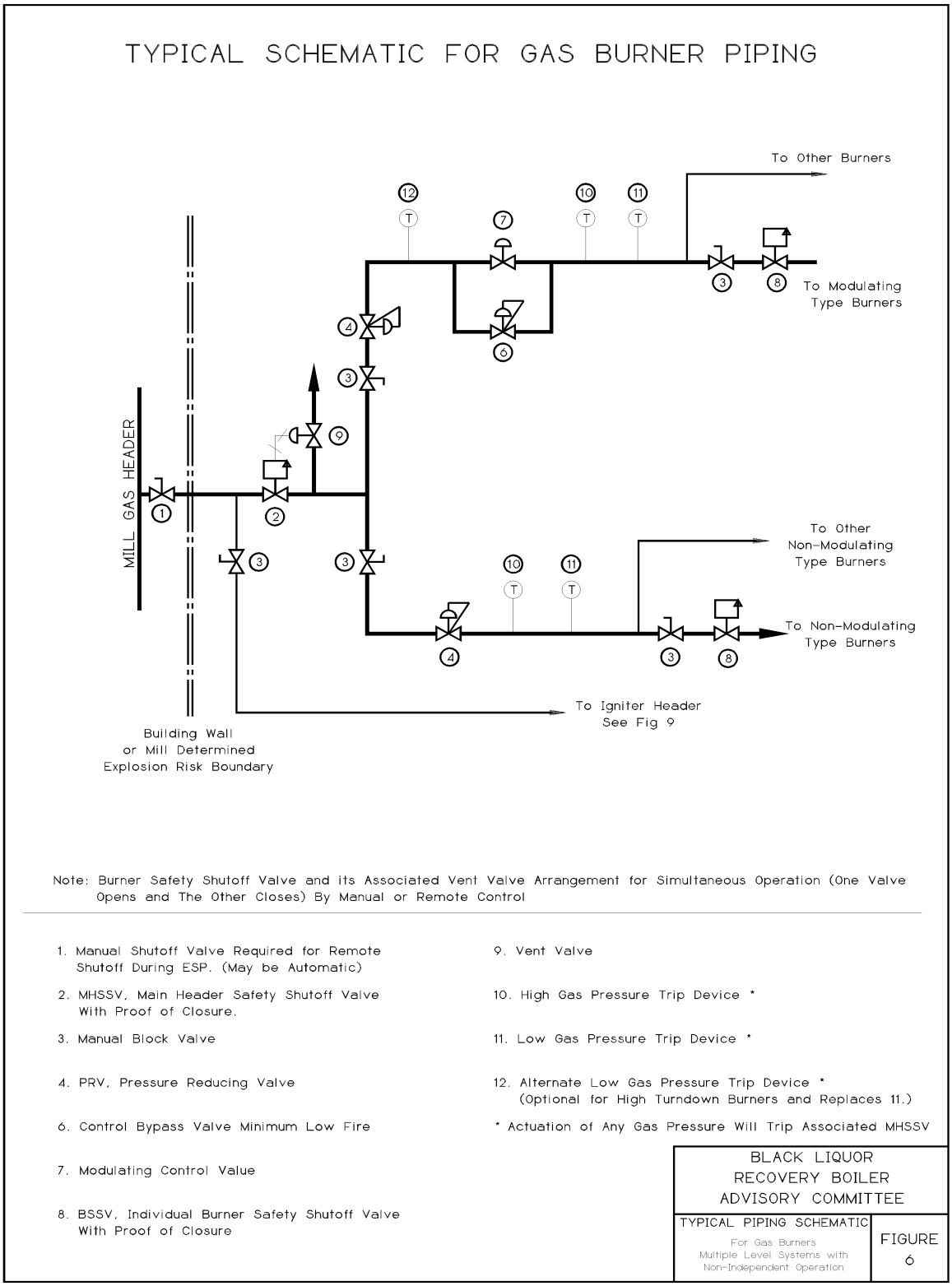

Fig. 6. Typical Schematic for Gas Burner Piping, Multi-Level, Non-Independent Operation.

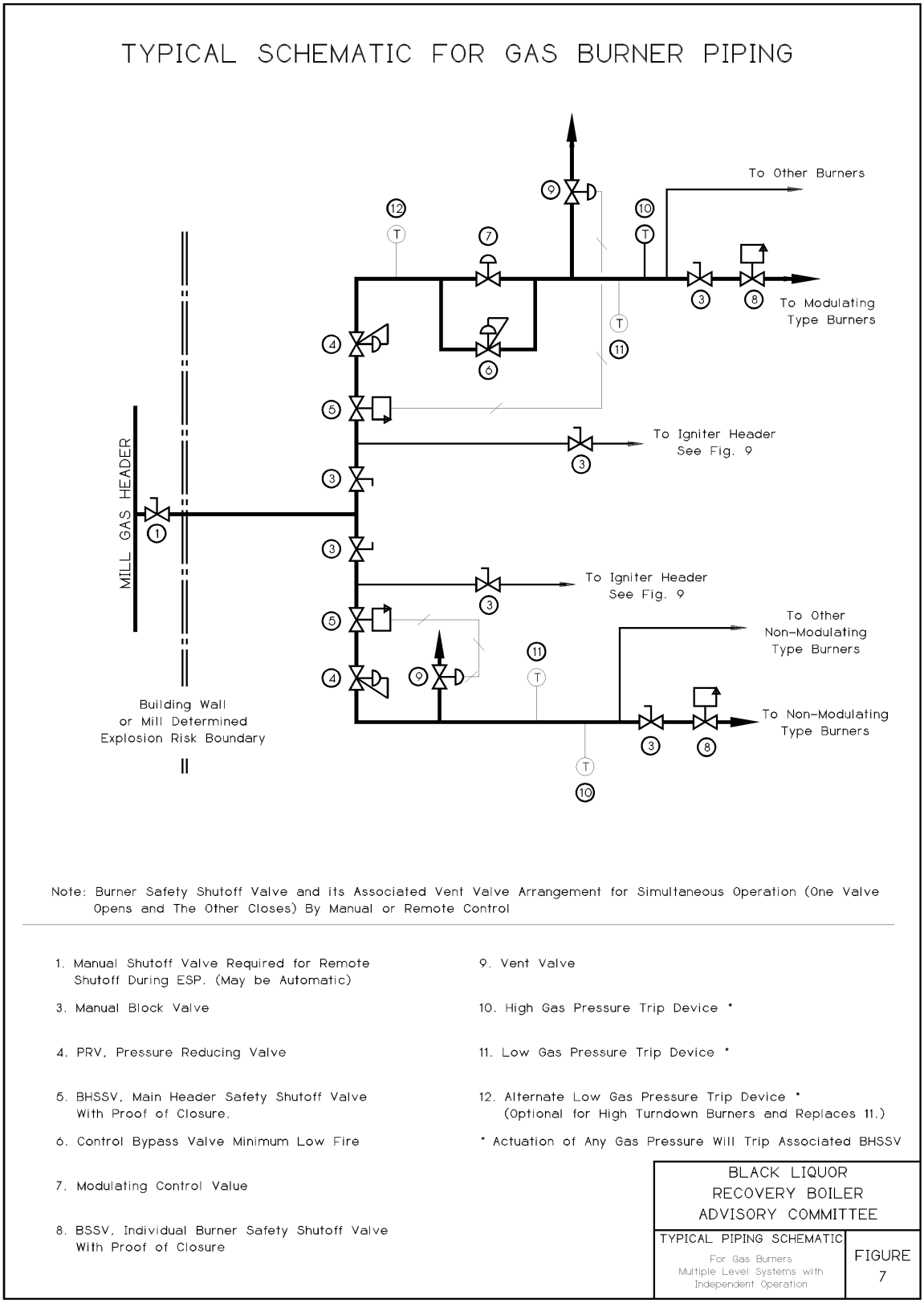

Fig. 7. Typical Schematic for Gas Burner Piping, Multi-Level, Independent Operation.

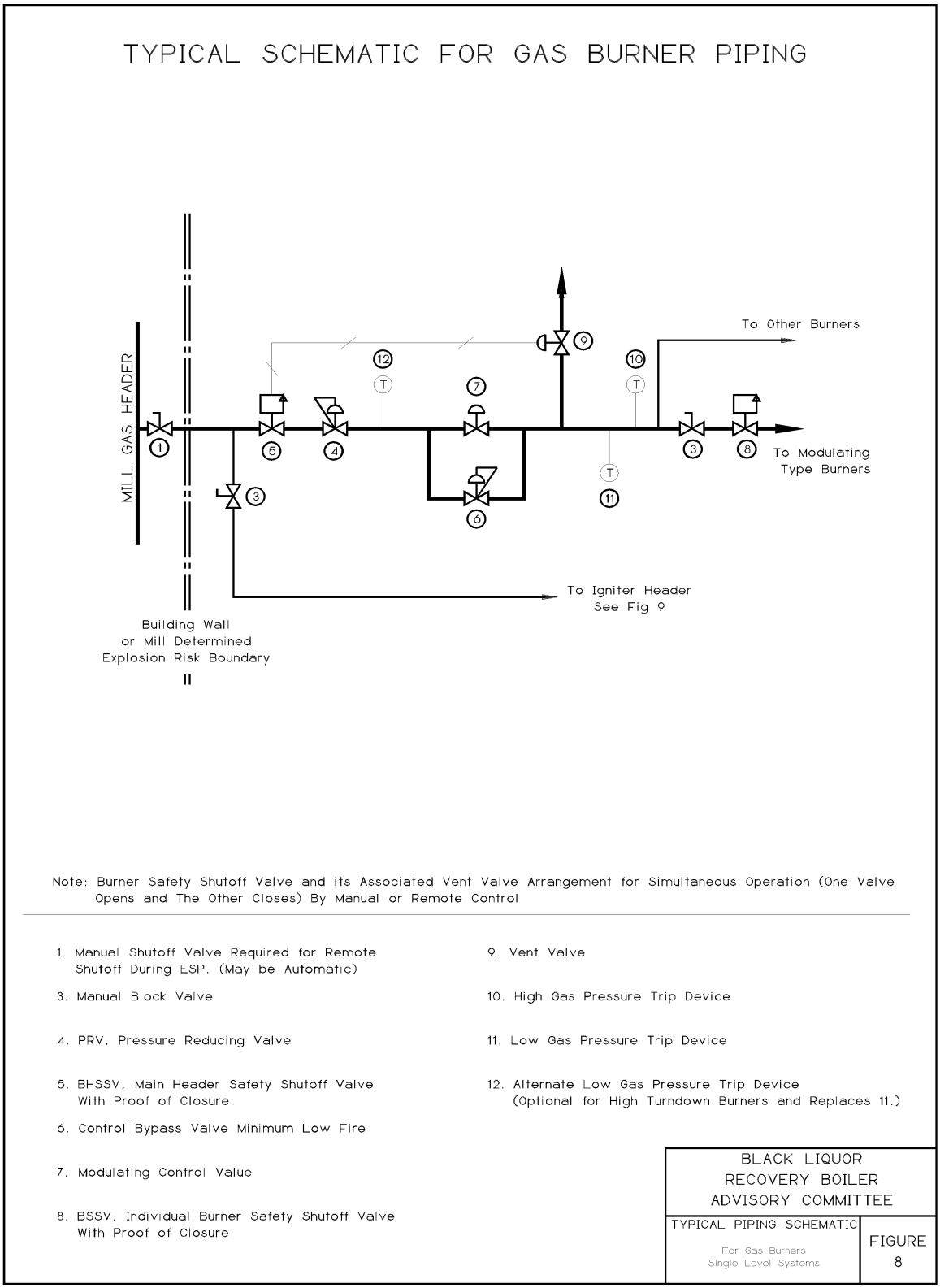

Fig. 8. Typical Schematic for Gas Burner Piping, Single Level Systems.

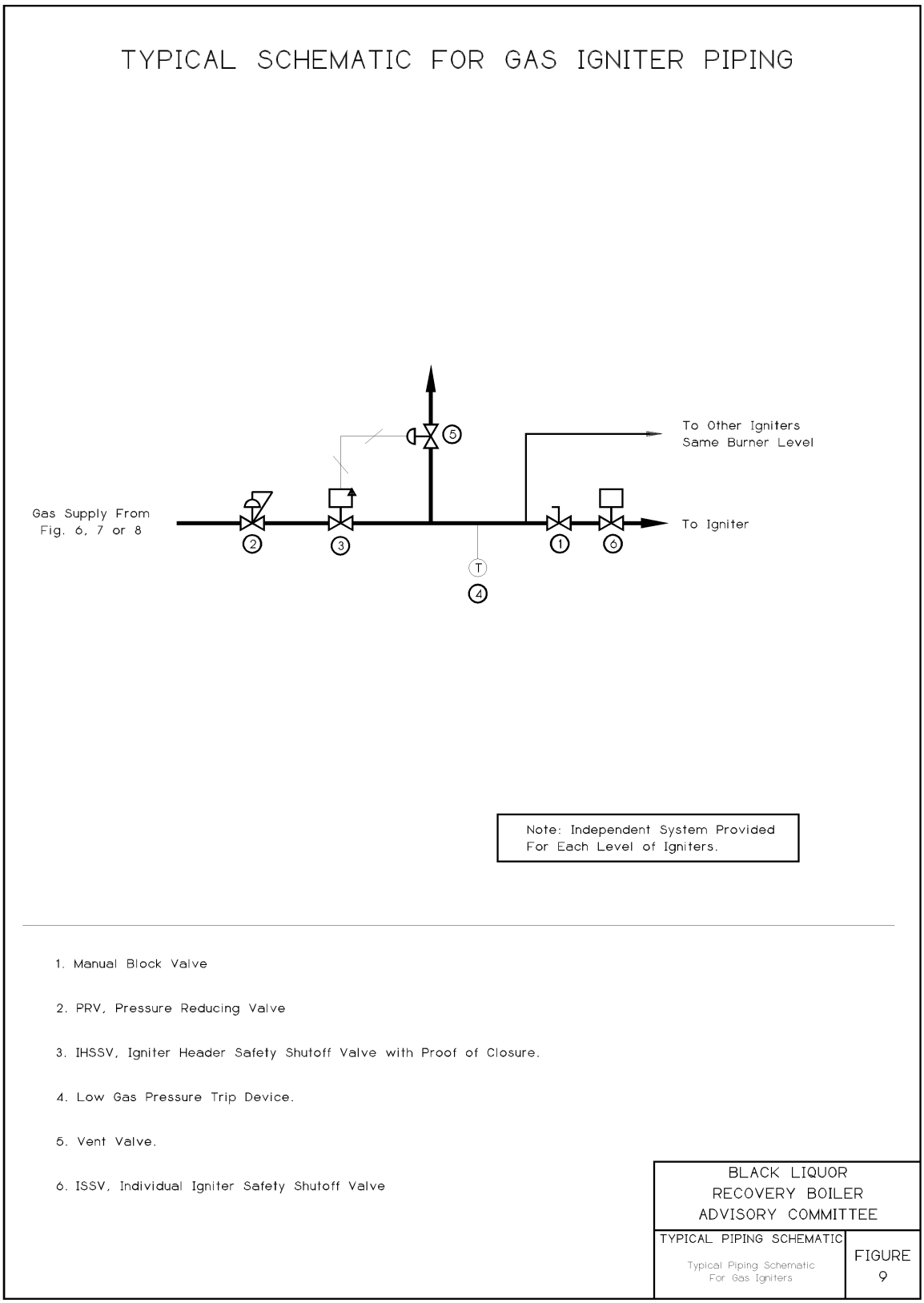

Fig. 9. Typical Schematic for Gas Igniter Piping.

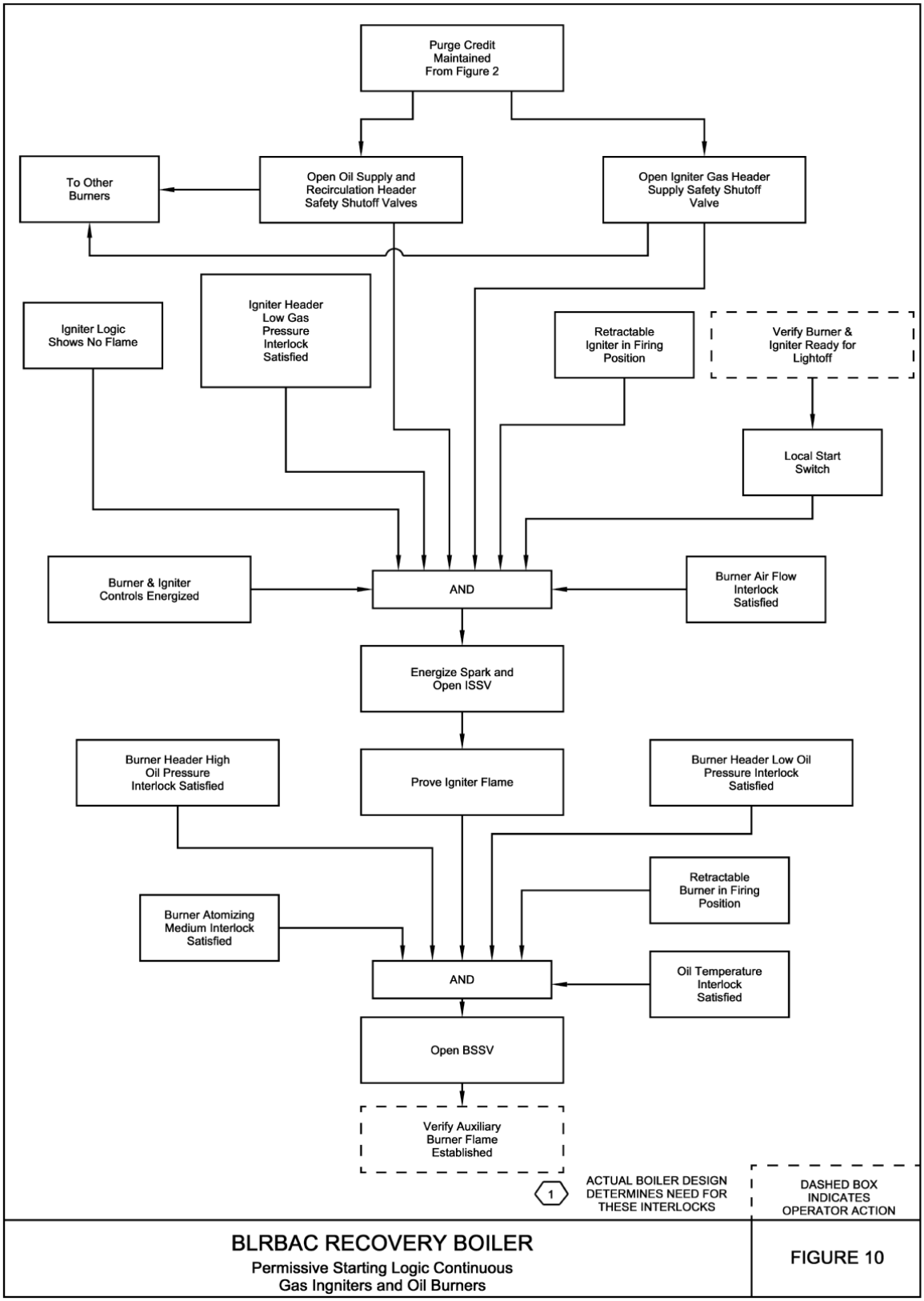

Fig. 10. Permissive Starting Logic Continuous Gas Igniters and Oil Burners.

Table 5. Logic Explanation Chart for Figure 10 – Permissive Starting Logic Continuous Gas Igniters and Oil Burners

Refer to Figure 10 Logic Explanation Chart Permissive Starting Logic Continuous Gas Igniters and Oil Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Open Oil Supply and Recirculation Header Safety Shut-off Valves	Supply oil to burner system prior to light-off.	
Purge Credit Maintained	Ensures all interlocks are satisfied.	
Open Igniter Gas Header Supply Safety Shut-off Valve	Supply gas to igniter system prior to light-off.	
Igniter Logic Shows No Flame	Prove flame sensor is not falsely indicating flame.	
Igniter Header Low Gas Pressure Interlock Satisfied	Detect abnormally low gas pressure. Set at 75% of normal supply pressure.	Insufficient ignition energy for burner.
Retractable Igniter in Firing Position	Ensure correct position for positive burner ignition.	Possible explosion from improper or delayed ignition.
Verify Burner & Igniter Ready for Light-Off	Operator to visually determine burner and igniter systems are ready for start-up and furnace opening is clear.	
Burner & Igniter Controls Energized	Provide power to burner and igniter safety control circuit. All safety devices should fail safe on loss of power.	
Local Start Switch	Ensure only local light off of burner.	
Burner Air Flow Interlock Satisfied	Ensure airflow through individual burners.	Possible explosion from improper fuel-air mixture.
Energize Spark and Open ISSV	Establish igniter flame in proper sequence.	
Prove Igniter Flame	Prove positive ignition source by a flame-supervising device.	Possible explosion if delayed burner ignition.
Oil Temperature Interlock Satisfied	Ensure suitable oil viscosity for proper atomization. (See Chapter 6)	
Burner Header High Oil Pressure Interlock Satisfied	Detect abnormally high oil pressure. Set at 125% of full load oil pressure.	Unstable burner conditions.
Burner Header Low Oil Pressure Interlock Satisfied	Detect abnormally low oil pressure. Set at minimum stable oil pressure.	Unstable burner conditions.
Burner Atomizing Medium Interlock Satisfied	Ensure that atomizing medium and oil pressure differential is correct.	Possible explosion from improper atomization.
Retractable Burner in Firing Position	Ensure correct position for proper burner operation. (See Chapter 6)	Possible explosion from improper or delayed ignition.
Open BSSV	Provide oil to burner in proper sequence.	
Verify Auxiliary Burner Flame Established	Operator to visually determine that the burner flame is established.	

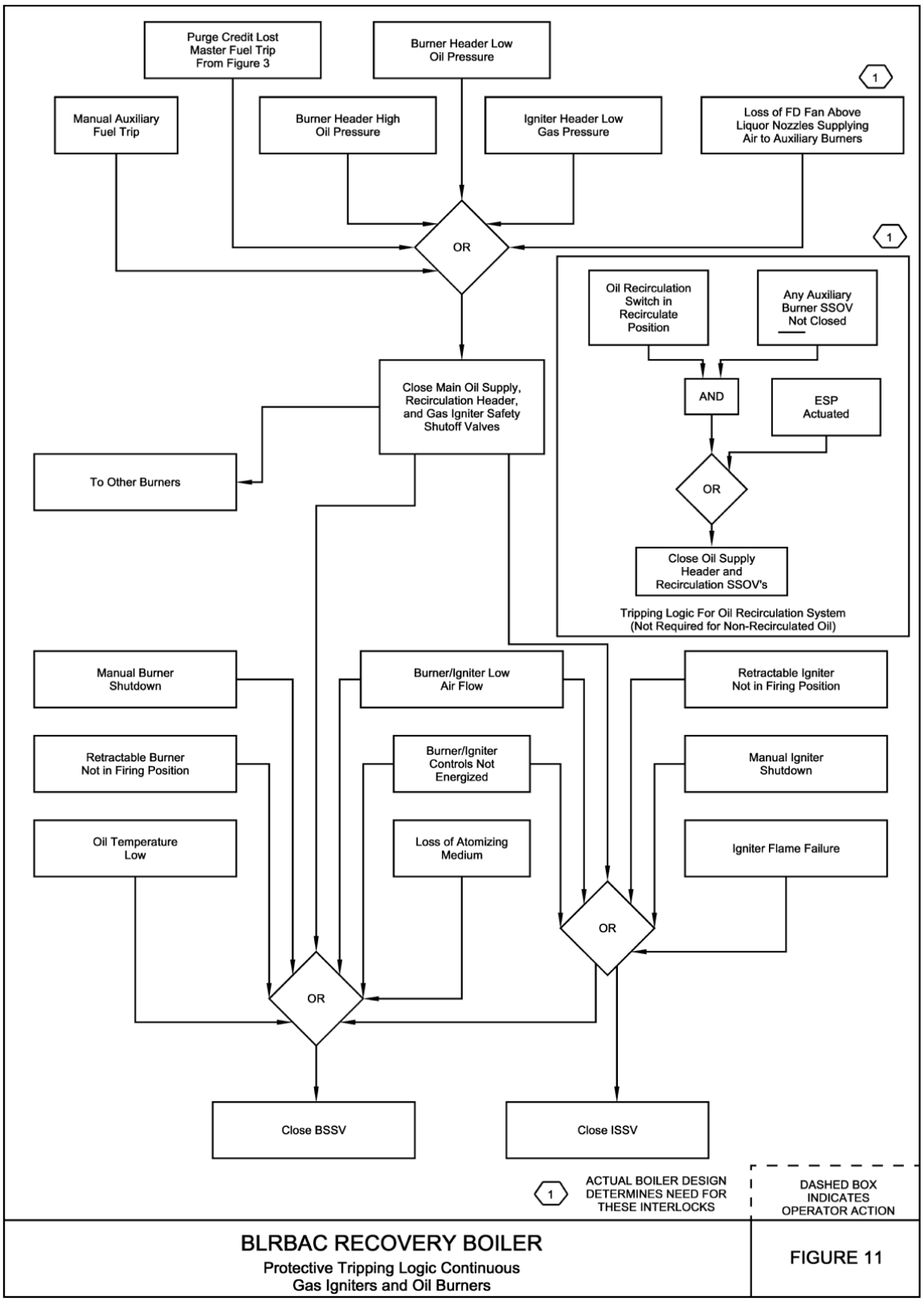

Fig. 11. Protective Tripping Logic Continuous Gas Igniters and Oil Burners.

Table 6. Logic Explanation Chart for Figure 11 – Protective Tripping Logic Continuous Gas Igniters and Oil Burners

Refer to Figure 11 Logic Explanation Chart Protective Tripping Logic Continuous Gas Igniters and Oil Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Purge Credit Lost Master Fuel Trip	Shut off all fuels to furnace.	Combustion of fuel with unsafe furnace condition.
Burner Header Low Oil Pressure	Shut off all oil to appropriate burner oil header if oil pressure drops below minimum stable burner oil pressure.	Unstable burner conditions.
Manual Auxiliary Fuel Trip	A remote manual device to shut off all auxiliary fuel to the furnace.	
Burner Header High Oil Pressure	Shut off appropriate burner oil header if oil pressure exceeds 125% of full load oil pressure.	Unstable burner conditions.
Igniter Header Low Gas Pressure	Shut off appropriate gas headers if gas pressure drops below 75% of normal supply pressure.	Unstable burner conditions from low igniter heat input.
Loss of FD Fan Above Liquor Nozzles Supplying Air to Auxiliary Burners	Shut-off auxiliary fuels associated with FD fan above liquor nozzles.	Possible explosion from accumulations of explosive mixtures.
Close Main Oil Supply, Recirculation Header, and Gas Igniter Safety Shutoff Valves	Ensure immediate and positive shutoff of all auxiliary fuels to furnace when required.	Possible explosion from continuing auxiliary fuel flows to furnace during unsafe conditions.
Burner/Igniter Low Air Flow	Shut off gas supply to an igniter and oil to its associated burner on loss of airflow.	Possible explosion from improper combustion.
Burner/Igniter Controls Not Energized	Shut off gas supply to an igniter and oil to its associated burner when power supply is interrupted.	Loss of power supply nullifies safeguards.
Loss of Atomizing Medium	Shutoff oil supply to burner if atomizing medium and oil pressure differential is incorrect.	Explosion from improper atomization.
Manual Burner Shutdown	Initiate normal shutdown of burner.	
Retractable Burner Not in Firing Position	Shut off oil supply to the burner if burner is moved from its proper firing position.	Fire or explosion from improper location.
Oil Temperature Low	Shutoff oil supply to burner if oil temperature drops below the minimum necessary for proper viscosity for atomization.	Explosion from improper atomization.
Retractable Igniter Not in Firing Position	Shut off gas supply to the igniter if igniter is moved from its proper firing position.	Fire or explosion from improper location.
Manual Igniter Shutdown	Initiate normal shutdown of igniter.	

Refer to Figure 11 Logic Explanation Chart Protective Tripping Logic Continuous Gas Igniters and Oil Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Igniter Flame Failure	Shut off gas supply to an igniter and oil to its associated burner if the igniter flame fails.	Possible explosion from continuing gas flow to igniter and loss of burner ignition in case of igniter flameout.
Close BSSV	Ensure immediate and positive shutoff of oil supply to a burner when required.	Possible explosion from continuing oil flow to furnace during unsafe conditions.
Close ISSV	Ensure immediate and positive shutoff of gas supply to an igniter when required.	Possible explosion from continuing gas flow to furnace during unsafe conditions.
Oil Recirculation Switch in Recirculate Position	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.
Any Auxiliary Burner SSOV Not Closed	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.
ESP Actuated	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.
Close Oil Supply Header and Recirculation SSOV's	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.

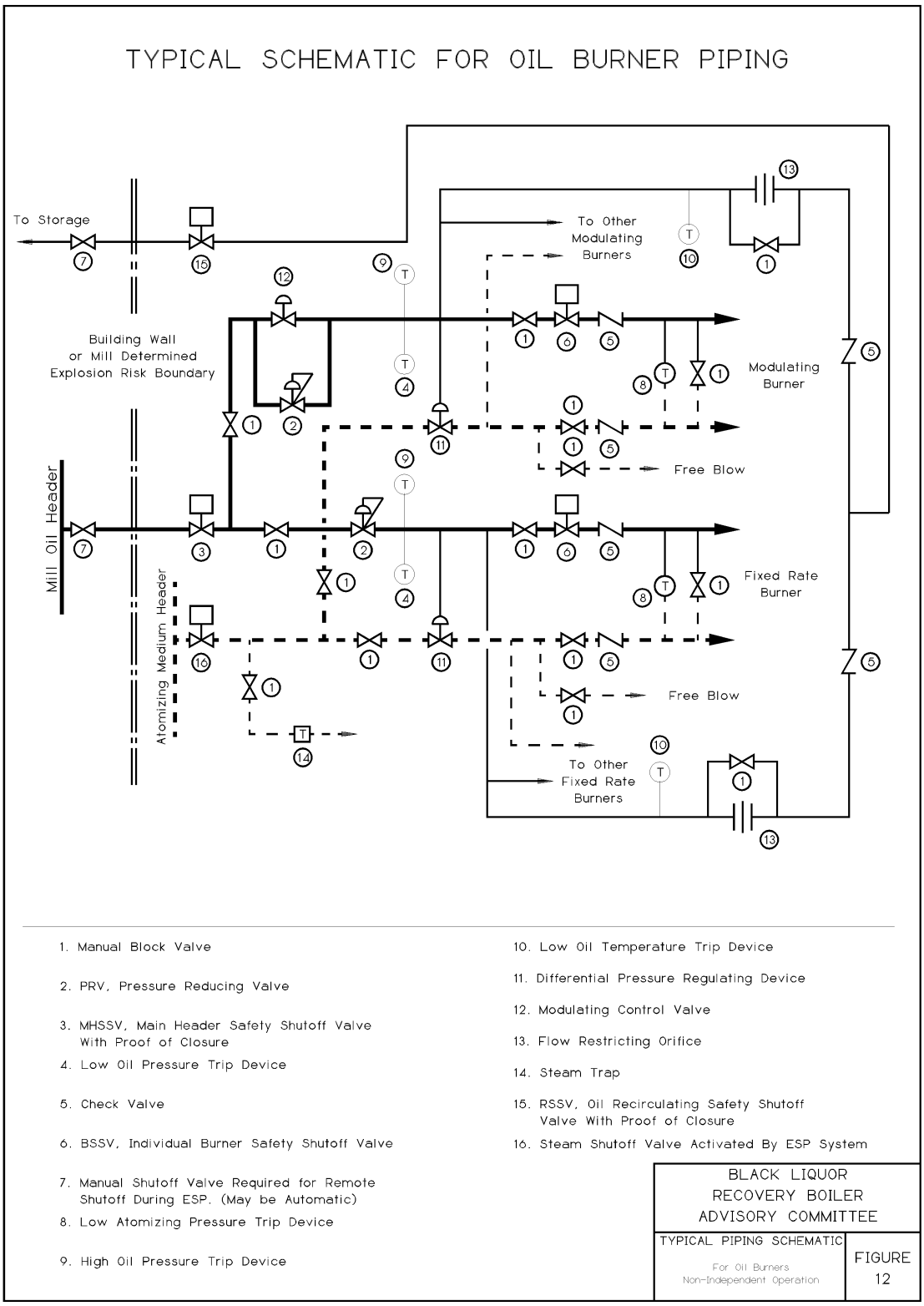

Fig. 12. Typical Schematic for Oil Burner Piping, Non-Independent Operation.

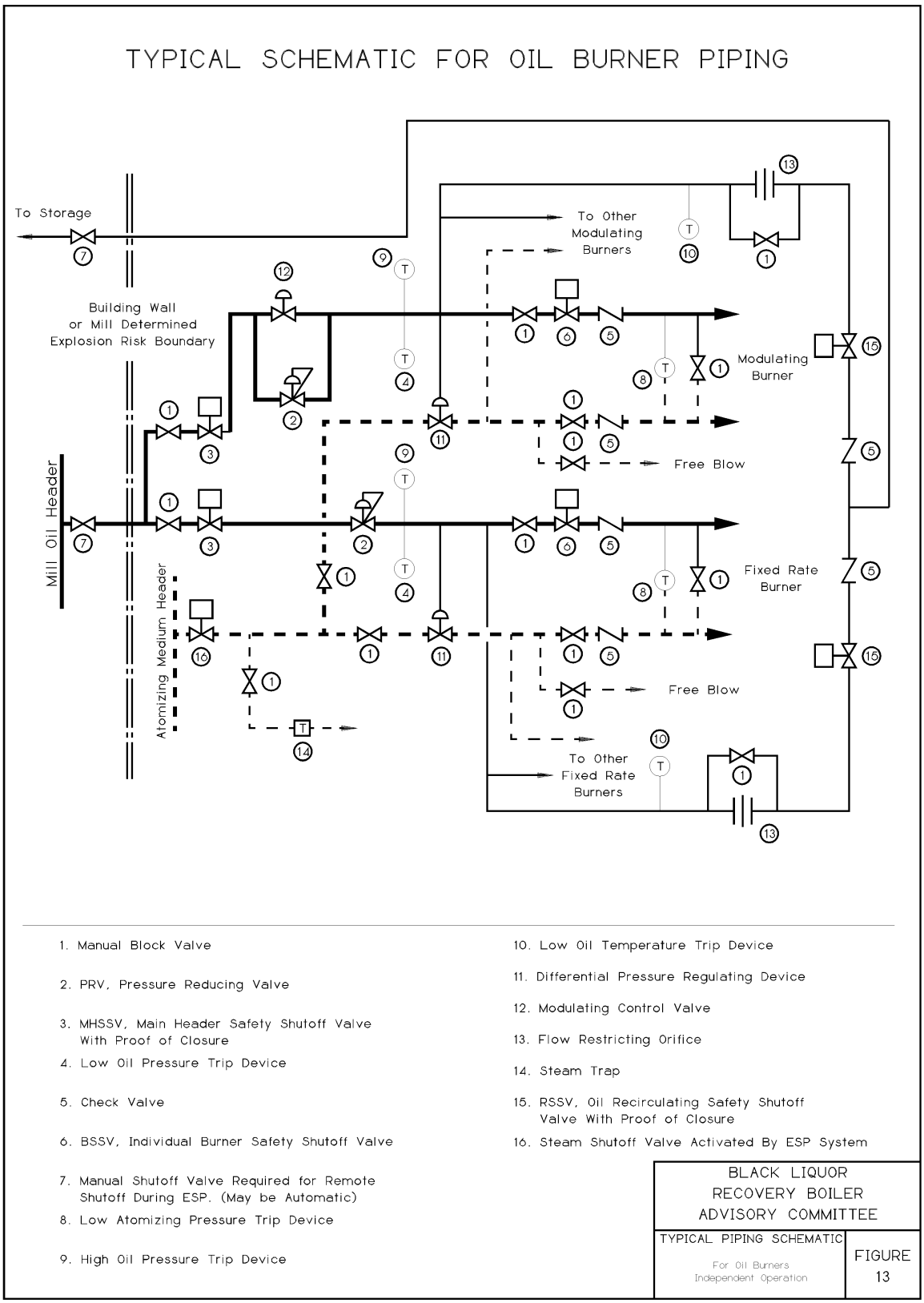

Fig. 13. Typical Schematic for Oil Burner Piping, Independent Operation.

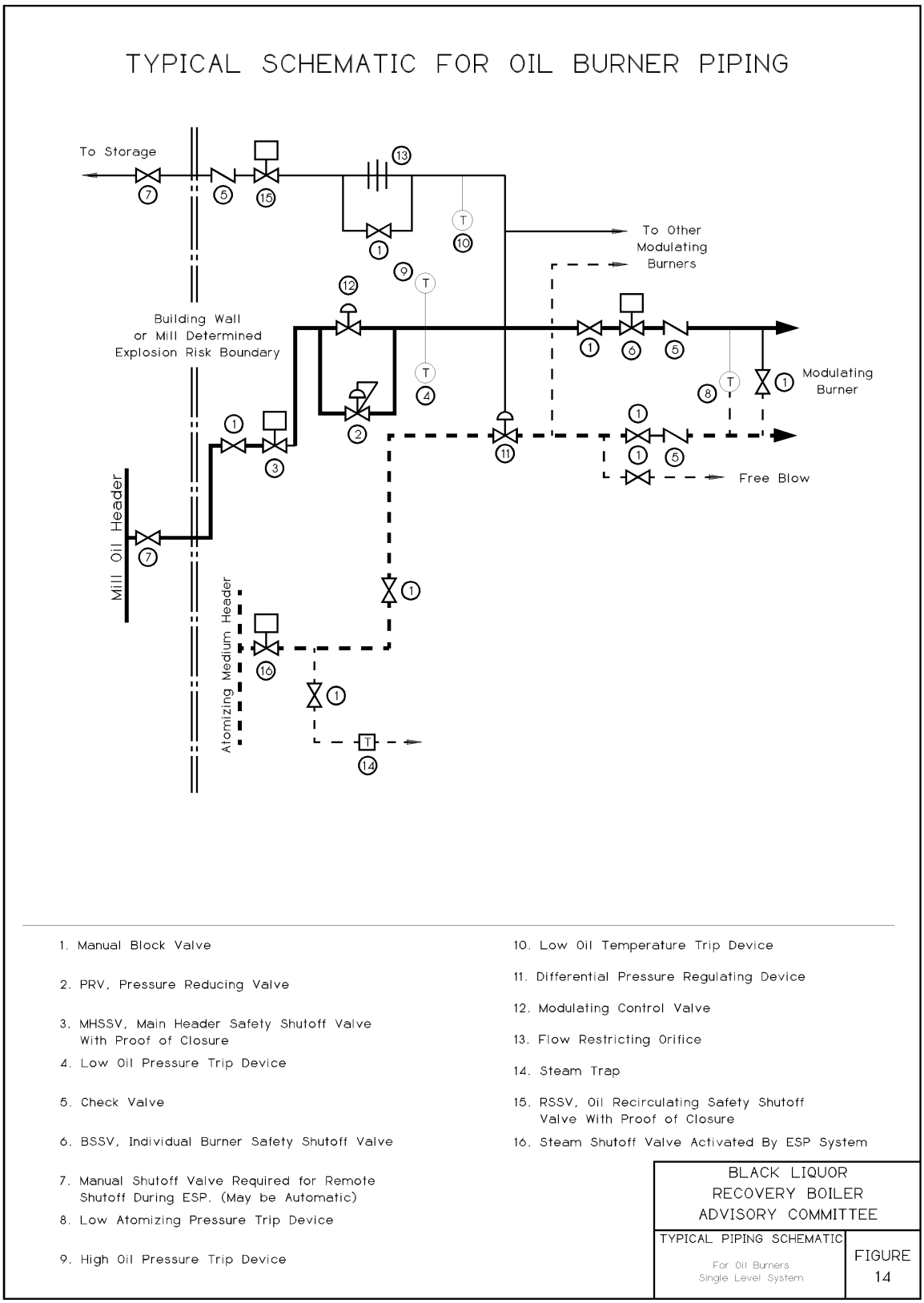

Fig. 14. Typical Schematic for Oil Burner Piping, Single Level Systems.

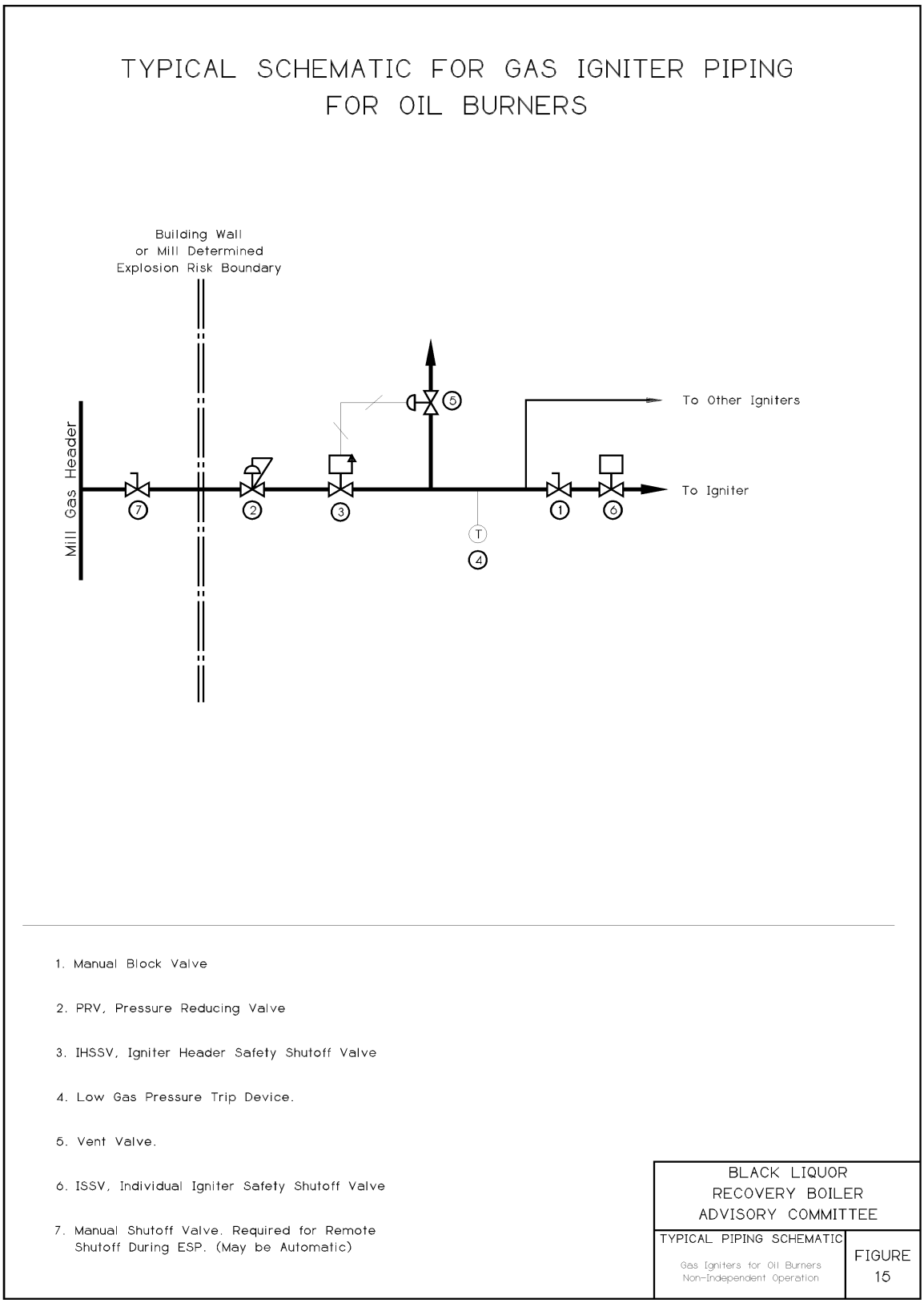

Fig. 15. Typical Schematic Gas Igniter for Oil Burners, Non-Independent Operation.

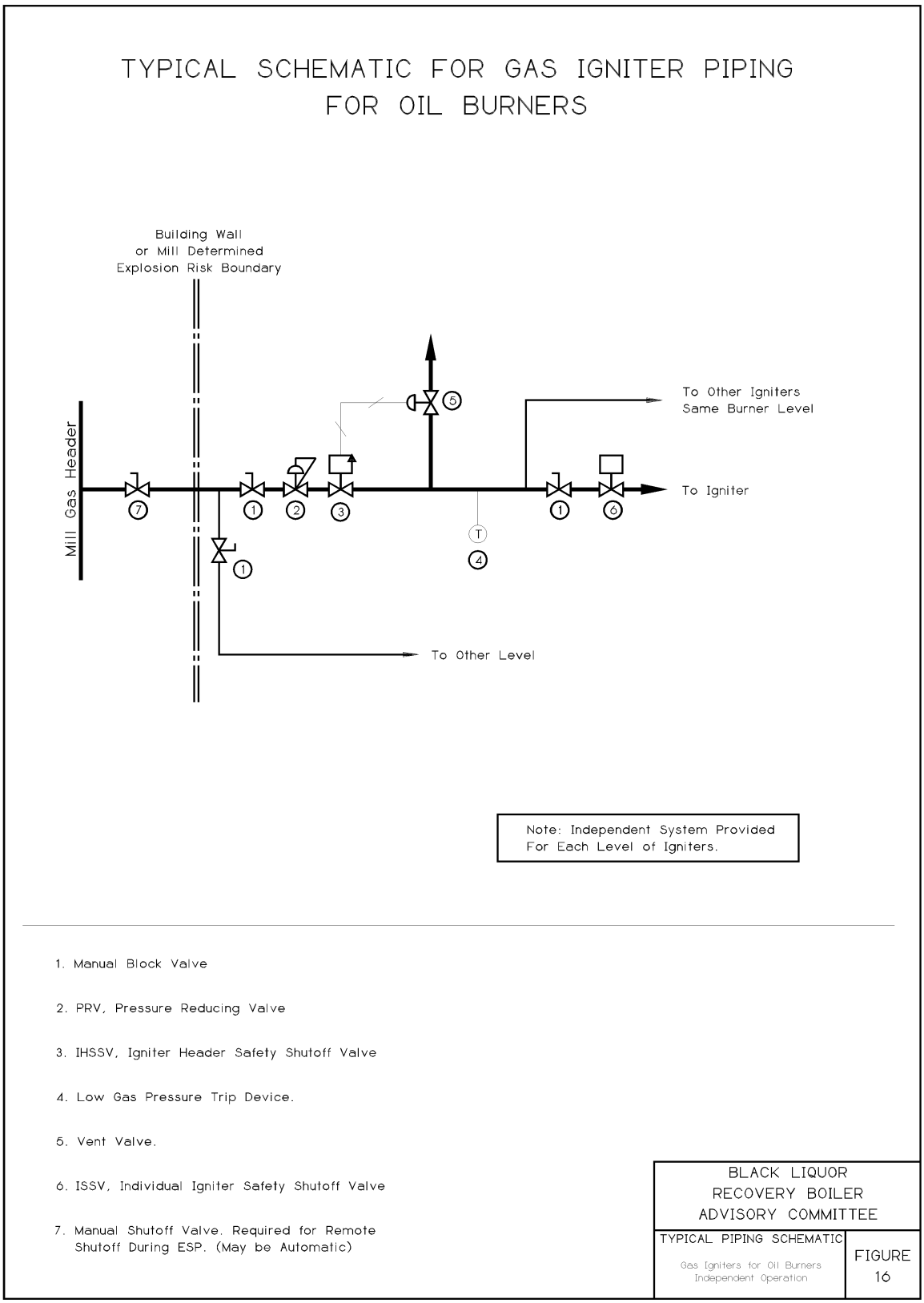

Fig. 16. Typical Schematic Gas Igniter for Oil Burners, Independent Operation.

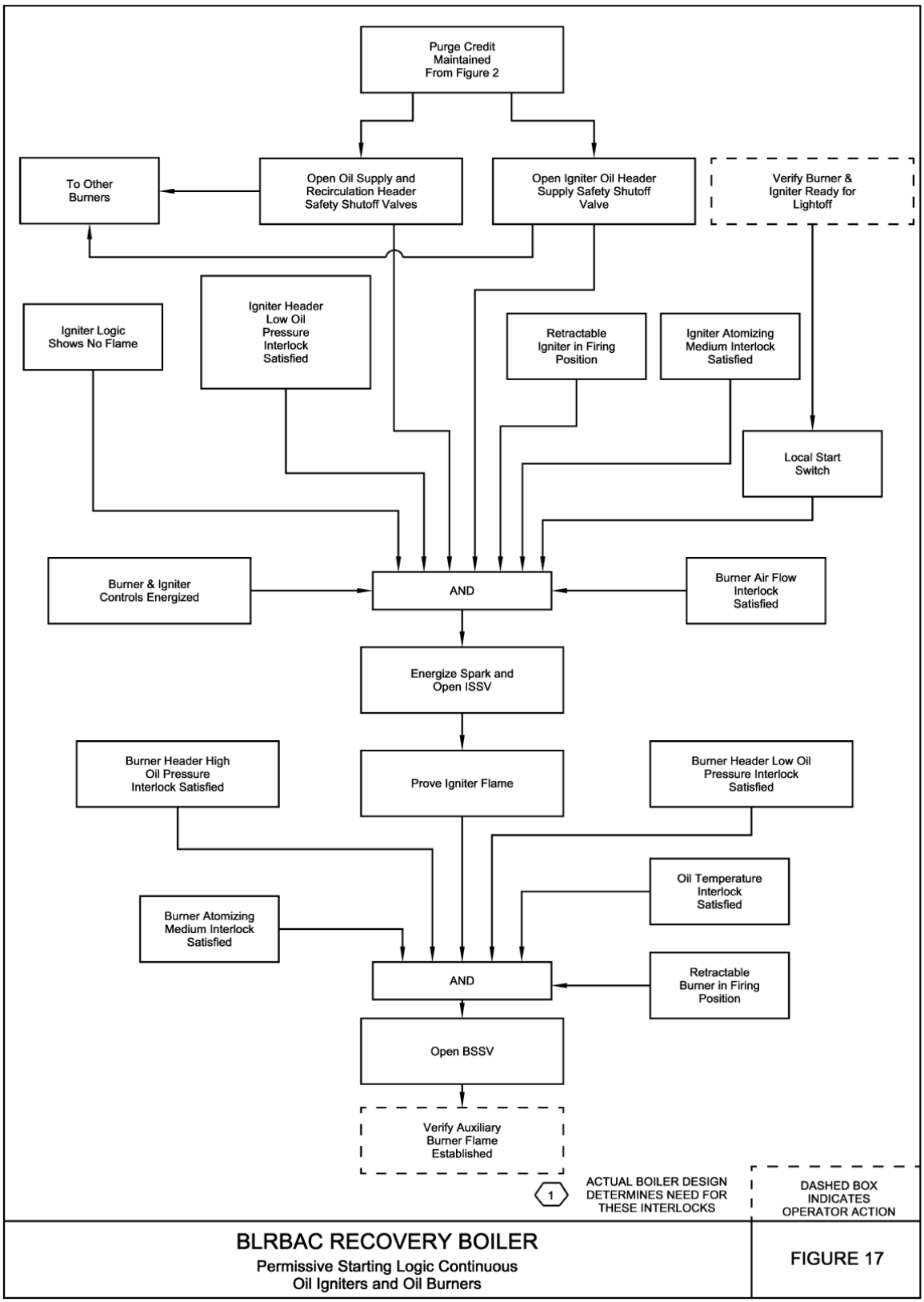

Fig. 17. Permissive Starting Logic for Continuous Oil Igniters and Oil Burners.

Table 7. Logic Explanation Chart for Figure 17 – Permissive Starting Logic Continuous Oil Igniters and Oil Burners

Refer to Figure 17 Logic Explanation Chart Permissive Starting Logic Continuous Oil Igniters and Oil Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Purge Credit Maintained	Ensures all interlocks satisfied.	
Open Oil Supply and Recirculation Header Safety Shutoff Valves	Supply oil to burner system prior to light-off.	
Open Igniter Oil Header Supply Safety Shutoff Valve	Supply oil to igniter system prior to light off.	
Igniter Logic Shows No Flame	Prove flame sensor is not falsely indicating flame.	
Igniter Header Low Oil Pressure Interlock Satisfied	Detect abnormally low oil pressure. Set at 75% of normal supply pressure.	Insufficient ignition energy for burner.
Retractable Igniter in Firing Position	Ensure correct position for positive burner ignition.	Possible explosion from improper or delayed ignition.
Igniter Atomizing Medium Interlock Satisfied	Ensure igniter system atomizing medium adequate for proper igniter operation.	Fire and explosion from improper atomization. Delayed ignition of associated burners and inadequate burner supervision.
Verify Burner & Igniter Ready for Light-Off	Operator to visually determine burner and igniter systems are ready for start-up and furnace opening is clear.	
Burner & Igniter Controls Energized	Provide power to burner and igniter safety control circuit. All safety devices should fail safe on loss of power.	
Local Start Switch	Ensure only local light off of burner.	
Burner Air Flow Interlock Satisfied	Ensure airflow through individual burners.	Possible explosion from improper fuel-air mixture.
Energize Spark and Open ISSV	Establish igniter flame in proper sequence.	
Prove Igniter Flame	Prove positive ignition source by a flame-supervising device.	Possible explosion if delayed burner ignition.
Burner Header High Oil Pressure Interlock Satisfied	Detect abnormally high oil pressure. Set at 125% of full load oil pressure.	Unstable burner conditions.
Burner Header Low Oil Pressure Interlock Satisfied	Detect abnormally low oil pressure. Set at minimum stable oil pressure.	Unstable burner conditions.
Oil Temperature Interlock Satisfied	Ensure suitable oil viscosity for proper atomization. (See Chapter 6)	Possible explosion from improper atomization.
Burner Atomizing Medium Interlock Satisfied	Ensure that atomizing medium and oil pressure differential is correct.	Possible explosion from improper atomization.
Retractable Burner in Firing Position	Ensures correct position for proper burner operation. (See Chapter 6)	Possible explosion from improper or delayed ignition.
Open BSSV	Provide oil to burner in proper sequence.	
Verify Auxiliary Burner Flame Established	Operator to visually determine that the burner flame is established.	

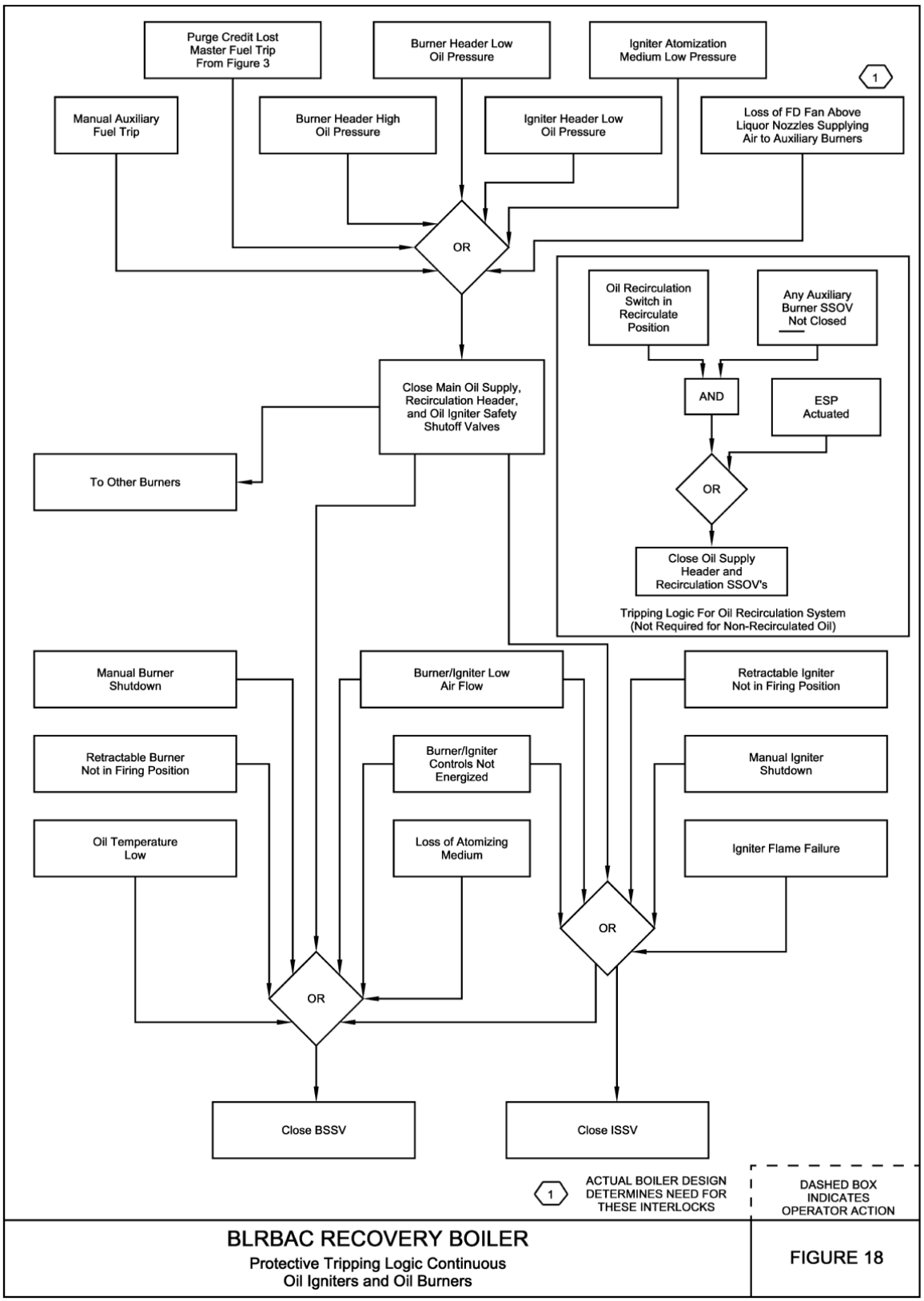

Fig. 18. Protective Tripping Logic Continuous Oil Igniters and Oil Burners.

Table 8. Logic Explanation Chart for Figure 18 – Protective Tripping Logic Continuous Oil Igniters and Oil Burners

Refer to Figure 18 Logic Explanation Chart Protective Tripping Logic Continuous Oil Igniters and Oil Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Purge Credit Lost Master Fuel Trip	Shut off all fuels to furnace.	Combustion of fuel with unsafe furnace condition.
Burner Header Low Oil Pressure	Shut off all oil to appropriate burner oil header if oil pressure drops below minimum stable burner oil pressure.	Unstable burner conditions.
Igniter Atomization Medium Low Pressure	Shutoff all auxiliary fuel oil to furnace if atomizing medium is inadequate for proper igniter system operation.	Fire and explosion from improper atomization. Delayed ignition of associated burners and inadequate burner supervision.
Manual Auxiliary Fuel Trip	A remote manual device to shut off all auxiliary fuel to the furnace.	
Burner Header High Oil Pressure	Shut off appropriate burner oil header if oil pressure exceeds 125% of full load oil pressure.	Unstable burner conditions.
Igniter Header Low Oil Pressure	Shut off appropriate oil headers if oil pressure drops below 75% of normal supply pressure.	Unstable burner conditions from low igniter heat input.
Loss of FD Fan Above Liquor Nozzles Supplying Air to Auxiliary Burners	Shut-off auxiliary fuels associated with FD fan above liquor nozzles.	Possible explosion from accumulations of explosive mixtures.
Close Main Oil Supply, Recirculation Header, and Oil Igniter Safety Shutoff Valves	Ensure immediate and positive shutoff of all auxiliary fuels to furnace when required.	Possible explosion from continuing auxiliary fuel flows to furnace during unsafe conditions.
Burner/Igniter Low Air Flow	Shut off oil supply to an igniter and oil to its associated burner on loss of airflow.	Possible explosion from improper combustion.
Burner/Igniter Controls Not Energized	Shut off supply to an igniter and oil to its associated burner when power supply is interrupted.	Loss of power supply nullifies safeguards.
Loss of Atomizing Medium	Shutoff oil supply to burner if atomizing medium and oil pressure differential is incorrect.	Explosion from improper atomization.
Manual Burner Shutdown	Initiate normal shutdown of burner.	
Retractable Burner Not in Firing Position	Shut off oil supply to the burner if burner is moved from its proper firing position.	Fire or explosion from improper location.
Oil Temperature Low	Shutoff oil supply to burner if oil temperature drops below the minimum necessary for proper viscosity for atomization.	Explosion from improper atomization.
Retractable Igniter Not in Firing Position	Shut off oil supply to the igniter and oil to its associated burner if igniter is moved from its proper firing position.	Fire or explosion from improper location.
Manual Igniter Shutdown	Initiate normal shutdown of igniter.	

Refer to Figure 18 Logic Explanation Chart Protective Tripping Logic Continuous Oil Igniters and Oil Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Igniter Flame Failure	Shut off oil supply to an igniter and oil to its associated burner if the igniter flame fails.	Possible explosion from continuing oil flow to igniter and burner in case of igniter flameout.
Close BSSV	Ensure immediate and positive shutoff of oil supply to a burner when required.	Possible explosion from continuing oil flow to furnace during unsafe conditions.
Close ISSV	Ensure immediate and positive shutoff of oil supply to an igniter when required.	Possible explosion from continuing oil flow to furnace during unsafe conditions.
Oil Recirculation Switch in Recirculate Position	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.
Any Auxiliary Burner SSOV Not Closed	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.
ESP Actuated	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.
Close Oil Supply Header and Recirculation SSOV's	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.

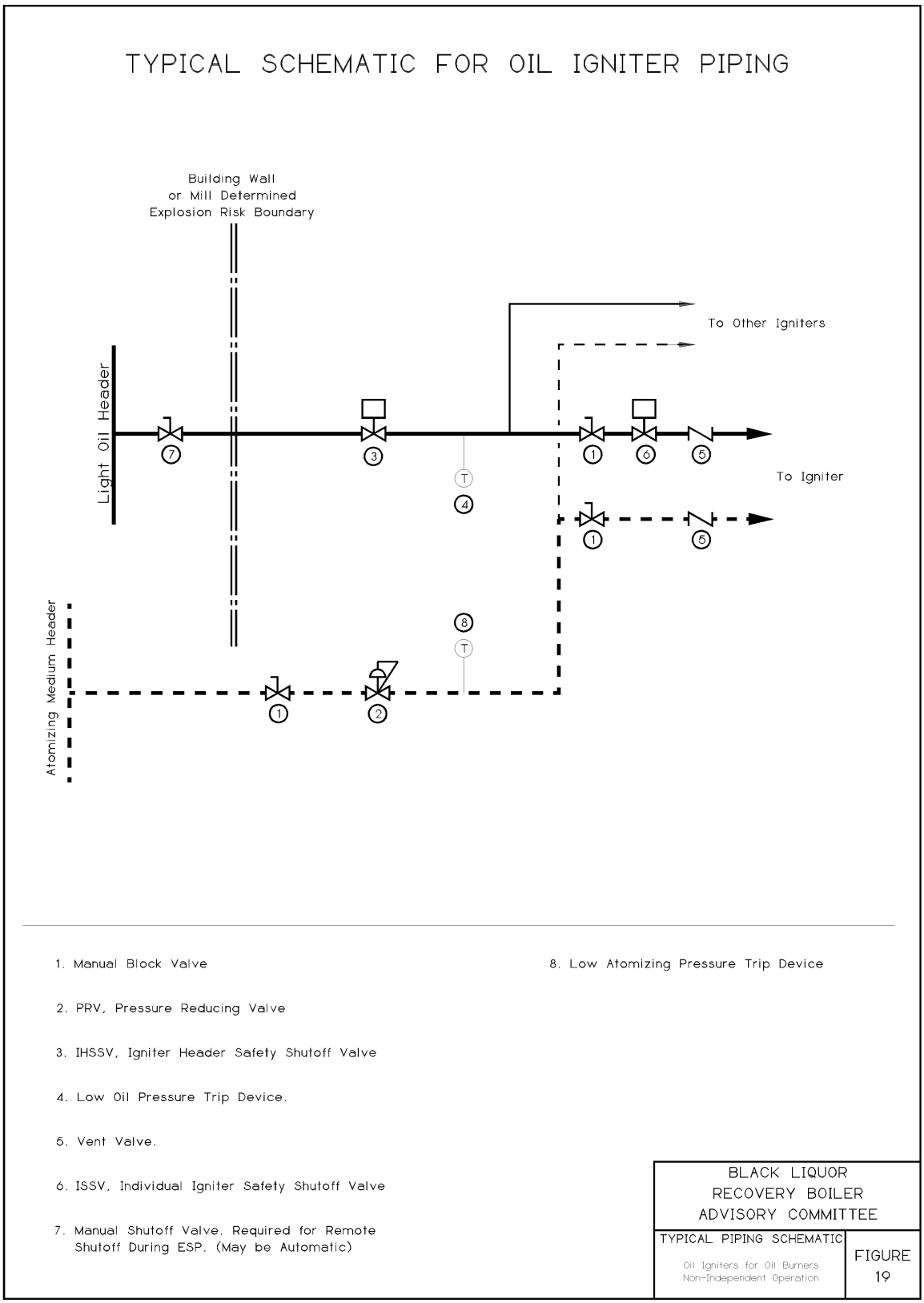

Fig. 19. Typical Schematic for Oil Igniter Piping Non-Independent Operation.

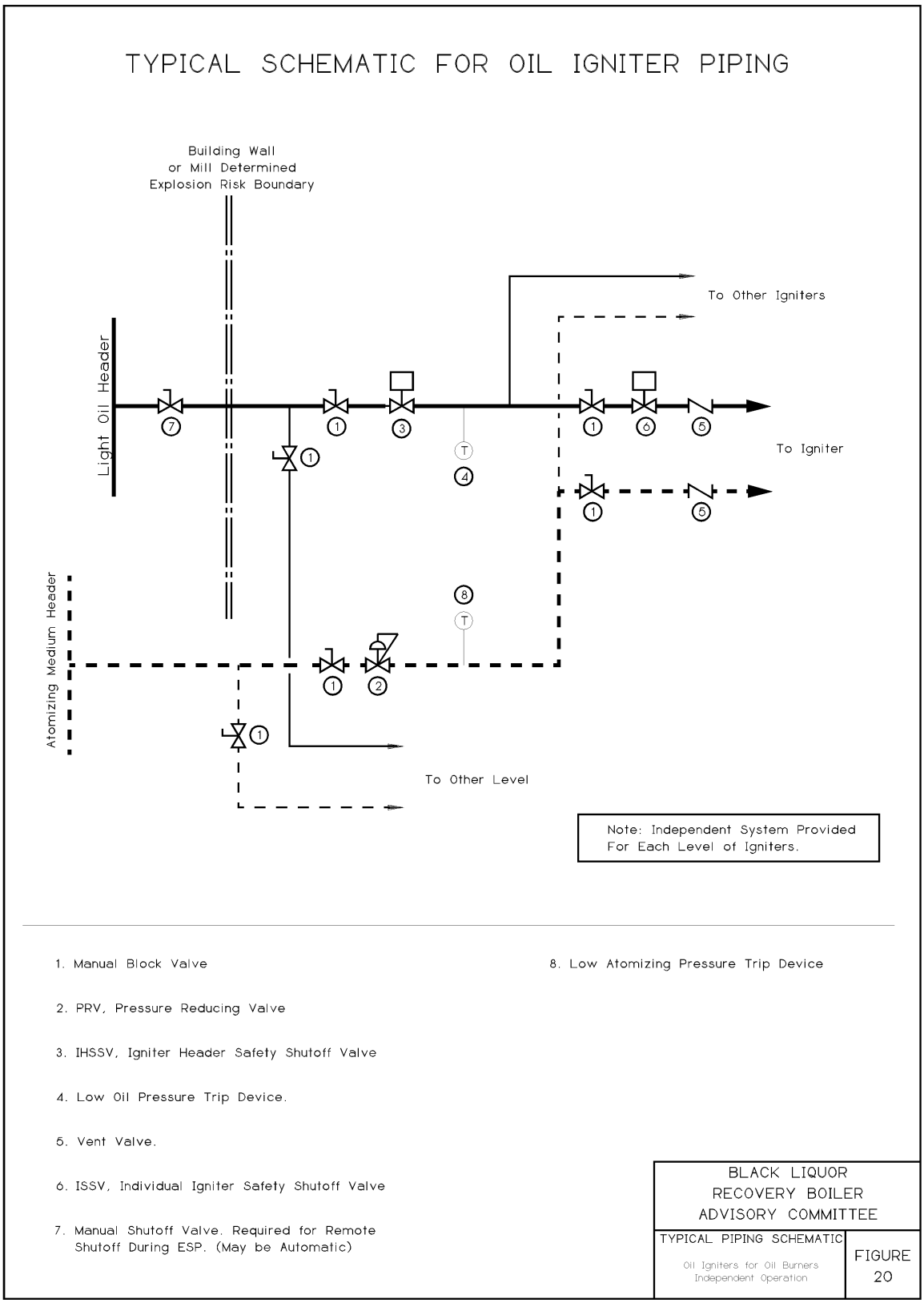

Fig. 20. Typical Schematic for Oil Piping Independent Operation.

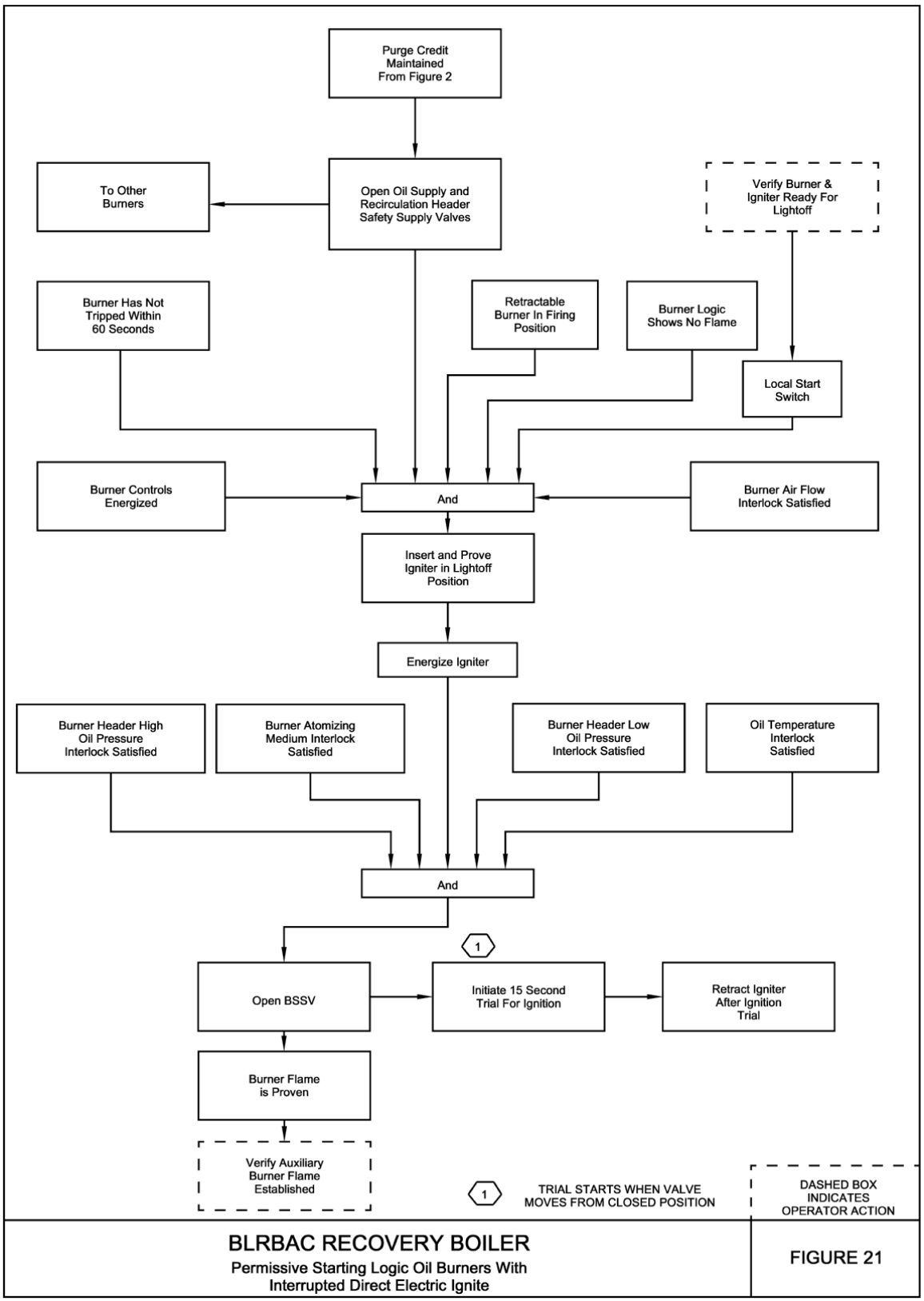

Fig. 21. Permissive Starting Logic Oil Burners with Interrupted Electric Igniters.

Table 9. Logic Explanation Chart for Figure 21 – Permissive Starting Logic Oil Burners with Interrupted Direct Electric Igniters

Refer to Figure 21 Logic Explanation Chart Permissive Starting Logic Oil Burners with Interrupted Direct Electric Igniters		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Purge Credit Maintained	Ensures all interlocks are satisfied.	
Open Oil Supply and Recirculation Header Safety Shut-Off Valves	Supply oil to burner system prior to light off.	
Burner Has Not Tripped Within 60 Seconds	Insure minimum burner purge between attempts to light the burner.	Possible explosion from localized accumulation of combustibles.
Retractable Burner in Firing Position	Insure correct position for proper burner operation. (See Chapter 6)	Possible explosion from improper or delayed ignition.
Burner Logic Shows No Flame	Prove flame sensor is not falsely indicating flame.	
Verify Burner and Igniter Ready for Light-Off	Operator to visually determine burner system is ready for start-up and furnace opening is clear.	
Local Start Switch	Insure only local light-off of burner.	
Burner Controls Energized	Provide power to burner safety control circuit. All safety devices should fail safe on loss of power.	
Burner Air Flow Interlock Satisfied	Insure airflow through individual burners.	Possible explosion from improper fuel-air mixture.
Insert and Prove Igniter in Light-Off Position	Prevent admitting oil to burner without igniter in proper position for light-off.	Possible explosion from improper or delayed ignition.
Energize Igniter	Provide oil to burner in proper sequence.	
Burner Header High Oil Pressure Interlock Satisfied	Detect abnormally high oil pressure. Set at 125% of full load oil pressure.	Unstable burner conditions.
Burner Atomizing Medium Interlock Satisfied	Insure that atomizing medium and oil pressure differential is correct.	Possible explosion from improper atomization.
Burner Header Low Oil Pressure Interlock Satisfied	Detect abnormally low oil pressure. Set at minimum stable oil pressure.	Unstable burner conditions.
Oil Temperature Interlock Satisfied	Insure suitable oil viscosity for proper atomization. (See Chapter 6)	Possible explosion from improper atomization.
Retract Igniter After Ignition Trial	Remove igniter from furnace.	
Initiate 15 Second Trail for Ignition	Limit time that unburned oil is admitted to the furnace.	Possible explosion from accumulation of combustibles in furnace.
Open BSSV	Provide oil to burner in proper sequence.	
Burner Flame is Proven	Prove burner flame by sensing system.	
Verify Auxiliary Burner Flame Established	Operator to visually determine that the burner flame is established.	

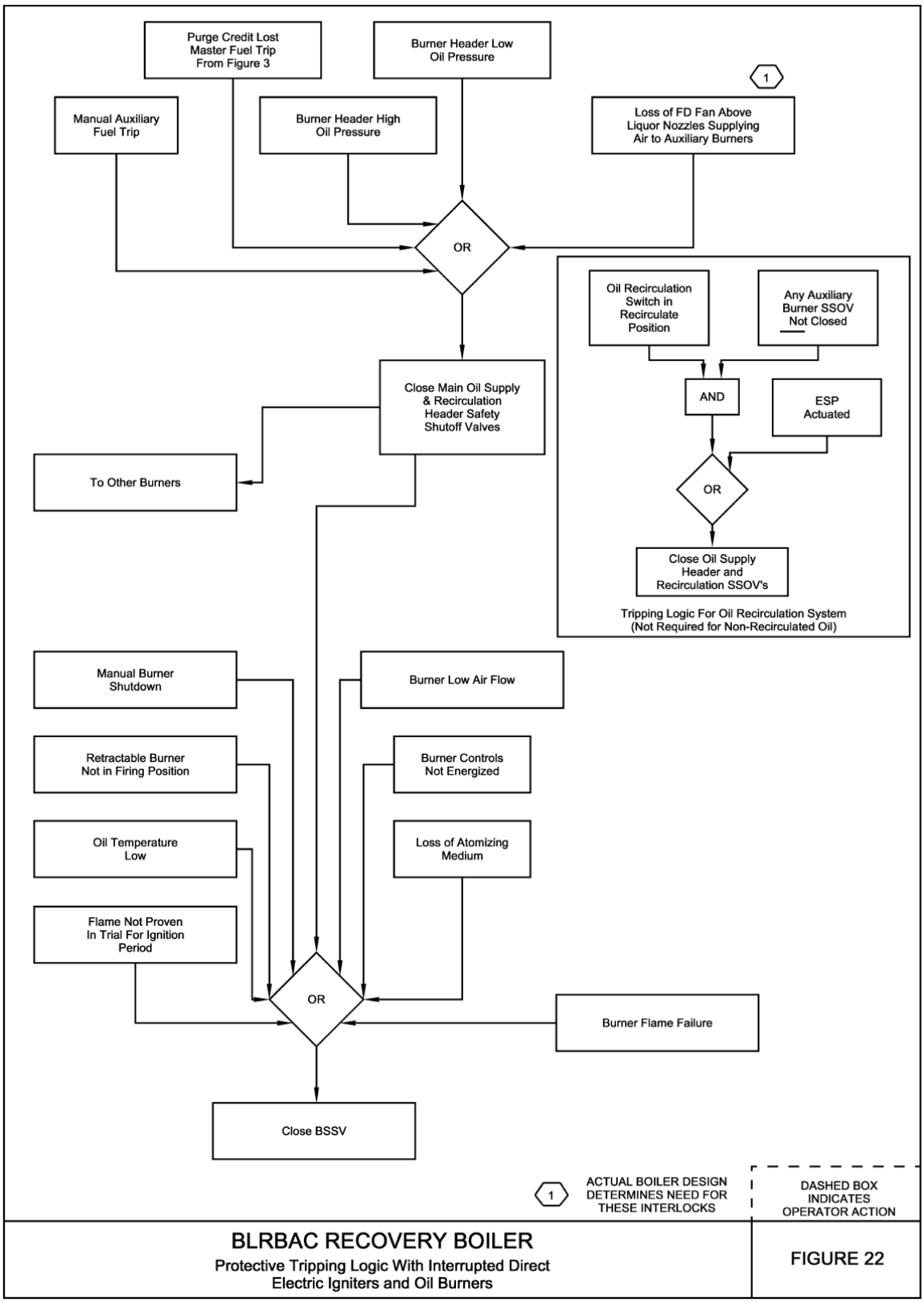

Fig. 22. Protective Tripping Logic Interrupted Direct Electric Igniters and Oil Burners.

Table 10. Logic Explanation Chart for Figure 22 – Protective Tripping Logic Interrupted Direct Electric Igniters and Oil Burners

Refer to Figure 22 Logic Explanation Chart Protective Tripping Logic Interrupted Direct Electric Igniters and Oil Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Purge Credit Lost Master Fuel Trip	Shut off all fuels to furnace.	Combustion of fuel with unsafe furnace condition.
Burner Header Low Oil Pressure	Shut off oil to appropriate burner header if oil pressure drops below minimum stable burner oil pressure.	Unstable burner conditions.
Manual Auxiliary Fuel Trip	A remote manual device to shut off all auxiliary fuel to the furnace.	
Burner Header High Oil Pressure	Shut off appropriate burner oil header if oil pressure exceeds 125% of full load oil pressure.	Unstable burner conditions.
Loss of FD Fan Above Liquor Nozzles Supplying Air to Auxiliary Burners	Shut-off auxiliary fuels associated with FD fan above liquor nozzles.	Possible explosion from accumulations of explosive mixtures.
Close Main Oil Supply and Recirculation Header Safety Shutoff Valves	Ensure immediate and positive shutoff of all auxiliary fuels to furnace when required.	Possible explosion from continuing auxiliary fuel flows to furnace during unsafe conditions.
Manual Burner Shutdown	Initiate normal shutdown of burner.	
Burner Low Air Flow	Shut off oil supply to an associated burner on loss of airflow.	Possible explosion from improper combustion.
Retractable Burner Not in Firing Position	Shut off oil supply to the burner if burner is moved from its proper firing position.	Fire or explosion from improper location.
Burner Controls Not Energized	Shutoff oil supply to the associated burner when power supply is interrupted.	Loss of power supply nullifies safeguards.
Oil Temperature Low	Shutoff oil supply to burner if oil temperature drops below the minimum necessary for proper viscosity for atomization.	Explosion from improper atomization.
Loss of Atomizing Medium	Shutoff oil supply to burner if atomizing medium and oil pressure differential is incorrect.	Explosion from improper atomization.
Flame Not Proven in Trial for Ignition Period	Shutoff oil supply to the burner if burner has failed to ignite.	Possible explosion from accumulation of combustibles in furnace.
Burner Flame Failure	Shutoff oil supply to the burner if burner flame is undetected.	Possible explosion from accumulation of combustibles in furnace.
Close BSSV	Ensure immediate and positive shutoff of oil supply to a burner when required.	Possible explosion from continuing oil flow to furnace during unsafe conditions.

Refer to Figure 22 Logic Explanation Chart Protective Tripping Logic Interrupted Direct Electric Igniters and Oil Burners		
Logic Diagram Block	**Purpose**	**Hazard Protected**
Oil Recirculation Switch in Recirculate Position	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.
Any Auxiliary Burner SSOV Not Closed	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.
ESP Actuated	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.
Close Oil Supply Header and Recirculation SSOV's	1 Stop recirculation of oil if any burner valve is opened. 2 Stop recirculation of oil in the event of an ESP.	1 Possible explosion from accumulation of combustible in furnace. 2 Possible fire from fuel line rupture as a result of a smelt-water reaction.

CHAPTER 5 AUDIBLE ALARMS AND VISUAL INDICATORS

5.1 General

A number of abnormal operating conditions can produce a potentially hazardous or dangerous condition for a black liquor recovery boiler. To assist the recovery boiler operator in the proper supervision of all functions, the control system should include audible alarms and visual indicators.

The purpose of alarms and indicators is to bring specific conditions to the attention of the operator and to indicate what the condition is. Alarms and indicators may be used to designate normal conditions, equipment malfunction, hazardous conditions, mis-operation, or operations required.

Alarms and indicators should be designed so the operator receives audible and visual indications as specified in the chart. Means may be provided to silence the audible alarm but the visual indicator should remain until the condition has been returned to normal. A "memory" feature should be incorporated so that notification of any transient condition that corrects itself will be retained until the operator acknowledges it. A "first-out" feature should be provided that indicates what occurred first in a sequence of events. First-out indication should be displayed at an attended work station.

5.2 Recommended Alarms and Indicators for Auxiliary Fuel Firing

The following table is a complete list of alarms and indicators recommended for auxiliary fuel firing.

Table 11. Audible Alarms and Visual Indicators Recommended for Auxiliary Fuel.

CONDITION	AUDIBLE ALARM	VISUAL INDICATOR	"FIRST OUT" FEATURE
1. PURGE IN PROGRESS		X	
2. PURGE COMPLETED		X	
3. INDIVIDUAL BURNER TRIPPED	X	X	
4. INDIVIDUAL BURNER VALVES CLOSED		X	
5. PURGE CREDIT LOST (MASTER FUEL TRIP)	X	X	X
6. MAIN HEADER AND MAIN IGNITER SAFETY SHUTOFF VALVES CLOSED		X	
7. FAILURE OF AUXILIARY FUEL TRIP VALVE TO CLOSE (MHSSV, IHSSV, BHSSV, BSSV, RSSV)	X	X	
8. INDIVIDUAL IGNITER OR BURNER FLAME FAILURE	X	X	
9. F. D. FAN(S) FAILURE	X	X	X
10. I. D. FAN(S) FAILURE	X	X	X
11. FUEL-GAS PRESSURE LOW	X	X	X
12. FUEL-GAS PRESSURE HIGH	X	X	X
13. FUEL-OIL PRESSURE LOW	X	X	X
14. FUEL-OIL PRESSURE HIGH	X	X	X

CONDITION	AUDIBLE ALARM	VISUAL INDICATOR	"FIRST OUT" FEATURE
15. FUEL-OIL TEMPERATURE LOW	X	X	X
16. AIR FLOW BELOW LIQUOR GUNS <30%	X	X	X
17. FURNACE PRESSURE HIGH TRIP	X	X	X
18. FURNACE PRESSURE LOW TRIP	X	X	X
19. DCE OUTLET GAS-TEMPERATURE HIGH TRIP	X	X	X
20. PRECIPITATOR OUTLET GAS-TEMPERATURE HIGH TRIP[1]	X	X	X
21. PRECIPITATOR INLET GAS TEMPERATURE HIGH TRIP [1]	X	X	X
22. DRUM LEVEL TRIP	X	X	X
23. BURNER FUEL-OIL ATOMIZING MEDIUM LOW	X	X	X
24. IGNITER OIL-ATOMIZING MEDIUM LOW	X	X	X
25. BURNER SYSTEM ENERGIZED		X	
26. BURNER AIRFLOW LOW	X	X	
27. STEAM FLOW <30% MCR TRIP		X	X
28. BLACK LIQUOR FLOW <30% MCR TRIP		X	X
29. NCG STREAM ISOLATED FROM FURNACE		X	
30. ESP ACTIVATED		X	X
31. PROVE LIQUOR OUT OF FURNACE		X	
32. MANUAL ACTUATION MASTER FUEL TRIP	X	X	X
33. MANUAL ACTUATION AUXILIARY FUEL TRIP	X	X	X
34. Water Wash Spool Piece Interlock		X	

Note: 1) Applies only to direct contact evaporator units or units with precipitators constructed of combustible material.

5.3 Other Audible Alarms and Visual Indicators

The following table of "OTHER AUDIBLE ALARMS AND VISUAL INDICATORS" (other than those for *Auxiliary Fuel*) are also recommended or suggested. Items designated by **"R"** are recommended and considered necessary for operation. Items designated by **"S"** are suggested and should be considered on an individual boiler basis.

Table 12. Other Audible Alarms and Visual Indicators and Visual Indicators

	CONDITION	AUDIBLE ALARM	VISUAL INDICATOR	R	S
A.	Spout Cooling System				
	1. Cooling water supply pressure low	X	X		X
	2. Cooling water conductivity high	X	X		X
B.	Dissolving Tank and Green Liquor System				
	1. Dissolving-tank level high	X	X		X
	2. Dissolving-tank level low	X	X	X	
	3. Dissolving tank density high	X	X	X	
	4. Dissolving tank density low	X	X		X
	5. Dissolving tank agitator amps high	X	X	X	~~X~~
	6. Dissolving tank agitator amps low	X	X	X	
	7. Green-liquor-transfer pump(s) stopped	X	X		X
	8. Green-liquor-recirculating pump(s) stopped	X	X		X

	CONDITION	AUDIBLE ALARM	VISUAL INDICATOR	R	S
C.	Black Liquor System				
	1. Supply pump(s) stopped (liquor to mix tank)		X		X
	2. Strainer drive(s) stopped	X	X		X
	3. Primary liquor heater temperature high	X	X		X
	4. Nozzle liquor temperature low	X	X	X	
	5. Nozzle liquor temperature high	X	X		X
	6. Manual B.L. trip	X	X	X	
	7. Salt cake feed system failure	X	X		X
	8. Evaporator drive(s) stopped	X	X	X	
	9. Evaporator circulating pump(s) stopped	X	X	X	
	10. Heavy liquor storage tank high/low level	X			X
	11. Precipitator/ash tank liquor level high/low	X	X		X
	12. Precipitator dust-recovery system failure	X	X		X
	13. Cascade level high	X	X		X
	14. Cascade level low	X	X	X	
	15. Cyclone evaporator sump level high	X	X		X
	16. Cyclone evaporator sump level low	X	X	X	
	17. Cyclone evaporator wall wash press. low	X	X	X	
	18. Cyclone evaporator wall wash press. high	X	X	X	
D.	Combustion Air and Flue Gas				
	1. F.D. fan discharge pressure low	X	X		X
	2. Primary air windbox pressure low	X	X		X
	3. Secondary air windbox pressure low	X	X		X
	4. Tertiary air windbox pressure low	X	X		X
	5. Oxygen level high	X	X		X
	6. Oxygen level low	X	X	X	
	7. Combustibles high	X	X		X
	8. Air heater temperature low	X	X		X
	9. Direct fired air heater temperature high	X	X	X	
	10. Direct fired air heater temperature low	X	X	X	
	11. Furnace pressure high	X	X	X	
	12. Furnace draft low	X	X	X	
	13. I.D. fan speed low	X	X		X
	14. DCE outlet temperature high	X	X	X	
	15. Precipitator outlet temperature high [1]	X	X	X	
	16. Precipitator inlet temperature high [1]	X	X	X	
E.	General				
	1. Precipitator power failure	X	X		X
	2. Precipitator insulator compartment fan failure	X			X
	3. Instrument air pressure low	X	X	X	
	4. Mill air pressure low	X			X
	5. Sootblower system trouble	X	X		X
	6. Opacity high	X	X		X
	7. TRS high	X	X		X
	8. SO_2 high	X	X		X
	9. NO_x high	X	X		X
F.	Feedwater, Steam and Auxiliaries [2]				
	1. Deaerator level low	X	X	X	
	2. Mill condensate return(s) contaminated	X	X	X	
	3. Feedwater pump(s) tripped	X	X	X	
	4. Feedwater supply pressure low	X	X	X	
	5. Deaerator pressure low	X	X	X	
	6. Cooling water system pressure low (for auxiliary equipment)	X	X		X
	7. Feedwater conductivity high	X	X	X	

	CONDITION	AUDIBLE ALARM	VISUAL INDICATOR	R	S
	8. Primary superheater temperature high	X	X		X
	9. Superheater outlet temperature high	X	X	X	
	10. Superheater outlet temperature low	X	X	X	
	11. Attemperator water flow high	X	X		X
	12. Electromatic/superheater vent open		X	X	
	13. Superheater tube metal temperature high	X	X		X
	14. ESP system drain valves open		X	X	
	15. ESP system drain valves closed		X		X
	16. ESP system FW stop valve open		X		X
	17. ESP system FW stop valve closed		X	X	

Notes:

1) Applies only to direct contact evaporator units or units with precipitators constructed of combustible material.

2) Include other pertinent system components as dictated by the feedwater treatment and supply system design.

CHAPTER 6

6.1 Discussion and Background Information

This chapter summarizes the discussions held and background information used by the Subcommittee on Safe Firing of Auxiliary Fuel in Black Liquor Recovery Boilers in preparing this document.

6.1.1 Furnace Purge

The subcommittee discussed the requirement for purging on "any start or on any restart which follows tripping of the auxiliary fuel main header safety shut-off valve." The fundamental question raised was: Is an additional purge needed before lighting auxiliary fuel if black liquor is firing and the ventilation remains satisfactory? The subcommittee agreed that as long as air flow through the furnace is not below 30% of the normal air flow at maximum continuous rating (MCR) when firing black liquor and all conditions are satisfactory, there is no need to purge for an additional five minutes before opening the auxiliary fuel header valve. The five minute purge is intended for cold startup or for hot restarts when firing of all fuel has been lost (as would result from inadequate ventilation).

To clarify the answer, the subcommittee used the term "purge credit" to mean the condition established when the furnace has been purged for the required five minute period with proven air flow. This condition applies as long as all permissives for burning black liquor are within limits and air flow remains above purge air flow rate. The additional five minute purge would only be required upon loss of purge credit.

6.1.2 Steam and Black Liquor Flows

The committee decided that minimum steam and liquor flow requirements should be set to assure stable enough furnace operation to allow maintaining the purge credit. A minimum of 30% of the maximum continuous rating of steam and black liquor flows was chosen as the minimum acceptable level for firing liquor unsupported by auxiliary fuel. This does not infer that successful sustained operation is possible at these values, only that combustion is sufficient to maintain the purge credit.

6.1.3 Furnace Pressure Trips

During the original development of the recommendations, a set point of +4 inches of water was chosen for high furnace pressure trip point because it seemed adequate to avoid nuisance trips in all normal operation of a recovery boiler and it eliminated the need for a time delay. Now, the recommendation is to set this trip point no greater than 80% of the static furnace design pressure. After further discussion, the subcommittee agreed that the high pressure trip point should be set as low as possible, to enable the fastest possible identification of tube ruptures and to increase personnel safety.

Low furnace pressure interlocks are recommended on furnaces not designed to withstand the maximum negative pressure that ID fans can impose on the furnace. Because low furnace pressure indicates operating problems, this interlock should also be considered for furnaces that would not be damaged by the ID fans.

6.1.4 Retractable Burner Assembly

The logic diagrams refer to a retractable igniter and retractable burner assembly. The term "retractable" means the device may be moved manually or with power assist. The intent of the recommendations is that if the device is physically movable and an attempt at firing could be made with it in an improper position, an interlock should be incorporated in the system to assure its being positioned properly for firing. Obviously, if the particular igniter/burner design does not have retractable units, there is no need for this interlock. Some manufacturers may supply an additional interlock to prove that a removable gas or oil gun has been properly coupled. However, this does not prove that the entire assembly is in the proper firing position.

6.1.5 Furnace Air Flow Trip

The subcommittee reconsidered where air flow should be measured. Some newer recovery boilers have sufficient auxiliary burner capacity to allow them to operate as power boilers when liquor is not available. Under this condition of operation, with the air introduced at the upper level burners, there may be insufficient air flow admitted below the liquor nozzles. Also, elevation of primary, secondary and tertiary air ports varies among boilers. Therefore, this requirement was clarified to require tripping the boiler when the air flow below the liquor nozzles is less than 30% of the total air flow required at MCR.

6.1.6 Precipitator Inlet and Outlet Temperature Trip

The subcommittee reviewed the need for tripping the boiler on excess precipitator inlet or outlet temperature. Due to the minimal loss experience with precipitators serving non-contact evaporators, the subcommittee agreed that a high temperature alarm is adequate if such precipitators contain no combustible materials of construction. Therefore, the interlock should be provided for precipitators containing any combustible construction and for precipitators serving direct contact evaporators, regardless of construction.

6.1.7 Relight Time Delay

With direct electric igniters, oil flows through the main burner during the trial for ignition period. If light-off is unsuccessful, at least ten times the amount of oil will accumulate than with oil-fired igniters. A 60-second time delay between relight attempts with minimum airflow of 30% MCR is needed to assure dissipation of oil vapors and prevent an unburned fuel explosion.

6.1.8 Burner Safety Shutoff Valves

In the permissive starting logic diagrams, the auxiliary fuel burner valves are proven closed just before the purge. It is acceptable to place this interlock earlier in the logic.

6.1.9 Steam Drum Water Level Satisfactory

In the permissive starting logic diagrams, drum water level is proven satisfactory after initiating the purge. It is acceptable to place this interlock earlier in the logic.

6.1.10 Gas Igniter - Gas Burner System, Igniter Fuel Shutoff Valves

A separate shutoff valve and vent is not required for the igniter system if burners and igniters are controlled by the same BHSSV. As shown on the schematics for non-independent operation, the combined igniter-burner system is controlled with a double valve and vent arrangement upon a trip condition, and is equivalent to the independent system.

In either igniter piping arrangement, it will be observed that while the permissive starting logic diagrams require the proving of all auxiliary fuel burner valves closed, they do not require the proving of igniter valves closed. This condition was accepted by the subcommittee on the basis that the quantity of gas introduced through the igniter line is very small, and the line is downstream of the MHSSV or IHSSV, which is proven closed. After the MHSSV or IHSSV are open, the amount of gas that might leak into the furnace through an open igniter valve can be dissipated by the purge air flow.

6.1.11 Fuel Pressure Interlocks

Fuel pressure interlocks may be moved upstream in both the starting logic diagram, as long as satisfactory fuel conditions are proven before any fuel valves are open.

6.1.12 Fuel Oil Recirculation

If heavy oil requiring preheating is used as the auxiliary fuel, provisions should be made to permit circulating the oil through the system to raise its temperature to the required value for safe burner operation. As it may be desirable to start the circulation of oil before placing the fans in service or satisfying other interlocks, the recommendations show a multiple position switch such that when in the RECIRCULATE position, it permits opening the MHSSV and the RSSV any time all the oil burner shutoff valves at the individual burners are proven closed. The circuitry should be such that if an individual oil burner shutoff valve is opened while the switch is in the RECIRCULATE position, the MHSSV and RSSV valves will close.

The system should be designed so when this switch is placed in the OPERATE position, the MHSSV and RSSV valves close automatically and may be reopened to fire oil only by satisfying the required interlocks.

To assure that hot oil is available continuously for the burners after the system has been properly activated, a small amount of oil is continually recirculated during normal operation. The piping diagram indicates that this is accomplished by placing an orifice in the return line. To accelerate the recirculation of oil on a cold start, a valved bypass is provided around the orifice. An alternate way of accomplishing this is to use a valve with a hole in the disc in the recirculating line, so that when the valve is closed it does not completely stop the circulation of oil.

6.1.13 Oil Recirculation Safety Shutoff Valve

The piping system for heavy oil-fired boilers shows an RSSV in the oil return line. The purpose of this valve is to prevent oil from reaching a shut down boiler from an active boiler through a common oil return line.

6.2 Deviations from Recommended Systems

6.2.1 Gas Igniter with Gas Burner

Variations in the arrangement and equipment for gas igniter with gas burner systems from the recommended piping diagram are permissible as long as the intent is retained. For example, the piping to one level of igniters could connect to the main gas supply between the BHSSV and the PRV for that level. The PRV in the line to the main burners can also be used as a modulating control valve by means of a loader which will permit altering the set point of the PRV to meet the load demand, and thus save the cost of an additional valve to adjust the firing rate.

6.2.2 Oil Temperature Interlock

The fuel oil system diagrams show oil temperature sensors for groups of burners, so a momentary or localized drop in temperature will trip all the burners in the group. An acceptable deviation from this would be to have a low oil temperature sensing device at each burner, so only the individual burner would trip. In this area some judgment should be exercised by the designer, giving due consideration to both reliability of the system and its cost.

6.2.3 Fuel Pressure Sensors

It is preferable to locate fuel pressure sensors as close to burners as possible. However, if a gas pressure sensor is not available for the range of all possible burner operating pressures, the sensor may be installed upstream of the regulating valve, provided that the startup logic correctly corresponds to the relative locations of the sensor, regulating valve and safety shutoff valve.

6.2.4 Modulating and Non-modulating Systems

Each piping schematic shows two systems for the main fuel: One with modulating means and one without. The modulating system is intended for burners used for bringing cold boilers into service or carrying load on the boiler when little or no liquor is being fired, when the ability to vary the firing rate is necessary. the non-modulating system is generally provided for low-capacity burners that are used primarily for operations related to firing liquor and normally fire at a fixed rate.

6.2.5 Diagram Details

The subcommittee did not attempt to show every valve required in each system, sizes of lines or the electrical circuitry. The objective was to develop a set of recommendations which, if followed, would achieve safe firing with minimum hardware. Nothing will cause operators to lose confidence in a system faster than one so complex that it is hard to understand, prevents starting the boiler readily, or causes it to trip out of service unexpectedly and without cause. While additional “fail safe” features might appear desirable, every piece of equipment added increases maintenance and chance of malfunction.

6.2.6 Piping Sizes

Fuel and/or atomizing medium piping have not always been sized adequately. Auxiliary burners in modern black liquor recovery boilers consume large quantities of fuel, requiring supply headers larger than many realize to assure proper pressure at the burners. In view of the importance of these systems, it is recommended that they be designed by qualified people.

6.2.7 Maintenance Provisions

An individual, manually operated plug cock or shutoff valve is recommended for each burner and igniter to permit maintenance of a burner without immobilizing the whole system. This plug cock, if provided, is independent of the manually operated supervisory cock.

6.2.8 Selection of System Components

The choice of electrical and mechanical equipment adequate for the duty and environment is very important. Because of the nature of the atmosphere surrounding the equipment and the extensive use of water for washing floors around recovery boilers, many accepted and listed devices suitable for other boiler applications are not adequate for this duty. All equipment should be at least “weatherproof” and in some cases “waterproof.” The intent of these devices can be defeated if electrical and piping connections to them have not been appropriately chosen and installed. Care should be taken to mount tripping devices and other sensitive instruments to avoid transmitting the normal vibrations associated with the operation of a black liquor recovery boiler to the

instruments. This may require the use of lengths of flexible conduit of waterproof design for electrical leads and flexible piping for fuel leads. Glass enclosures or inserts on instruments and control devices should be designed with a tight seal to prevent entrance of water to the device housings. These enclosures should also be located where they will not be exposed to mechanical damage.

6.2.9 Approved or Listed Components

While insurance companies generally prefer the use of approved or listed hardware, the peculiar environment surrounding black liquor recovery boilers is recognized and hardware that is not listed or approved may be accepted if the construction is at least equivalent to approved or listed devices and has the added features demanded by the black liquor recovery boiler application. Insurance companies should be consulted concerning the acceptability of specific equipment.

APPENDIX A DOCUMENT REVISION HISTORY

October 2010

In Fig. 2, *Common Permissive Starting Logic*, and Fig. 3, *Common Protective Tripping Logic*, the box stating: "Note: Incineration of Non-Condensible Gas Waste Streams is Not Encouraged by BLRBAC" has been deleted.

April 2009

Figure 2 (Common Permissive Starting Logic) and Table 1 (Logic Explanation Chart for Figure 2) have been revised to add permissives for dissolving tank level, spout cooling water flow, and smelt spouts being open. This matches the change made in Safe Firing of Black Liquor in the April 2009 revision of that document.

Table 2 (Logic Explanation Chart for Figure 3, Common Protective Tripping Logic) had a note added to clarify that an igniter should not be considered a burner. This matches the change made in Safe Firing of Black Liquor in the April 2009 revision of that document.

April 2007

Added a new logic block titled "Precipitator Inlet Temperature Below Prescribed Limits" to Fig. 2, *Common Permissive Starting Logic* with a corresponding change to *Table 1*, the accompanying logic explanation chart.

Added a new Logic Block titled "High Precipitator Inlet Temperature" to Fig. 3, *Common Protective Tripping Logic* with a corresponding change to *Table 2*, the accompanying logic explanation chart.

Added a new Condition titled "Precipitator Inlet Gas Temperature High Trip" as number 21 in *Table 11. Audible Alarms and Visual Indicators Recommended for Auxiliary Fuel* and renumbered subsequent numbers accordingly. Also, added a new item 34, "Water Wash Spool Piece Interlock."

Table 12, Other Audible Alarms and Visual Indicators

- Changed Dissolving tank agitator amps high from "Suggested" to "Recommended" for consistency with *Safe Firing of Black Liquor* and the *Instrumentation Checklist*.
- Added a new Condition titled "Precipitator inlet temperature high" as item D.14.

Modified section 6.1.6 to address both high precipitator inlet and outlet temperatures.

A note was added to Table 11 and Table 12 to clarify when high precipitator inlet and outlet temperature trips, alarms, and indicators apply.

October 2002

This document has been editorially revised to provide a consistent format.

The changes highlighted in red identify technical changes made to the document since the last published revision of November 1998 and include:

- The definitions for igniters have been modified and a section 3.4, Interrupted Igniters, has been added.

- "Sootblower Water Wash Spool Removed" has been added to the Common Permissive Starting Logic (Fig. 2) and to the accompanying explanation table.

- Text has been modified in section 4.5 to permit isolation valves in sensing lines of critical instruments.

This document was first issued in April 1967. A history of intermediate revisions between the initial issue and the October 2002 revision has not been created.