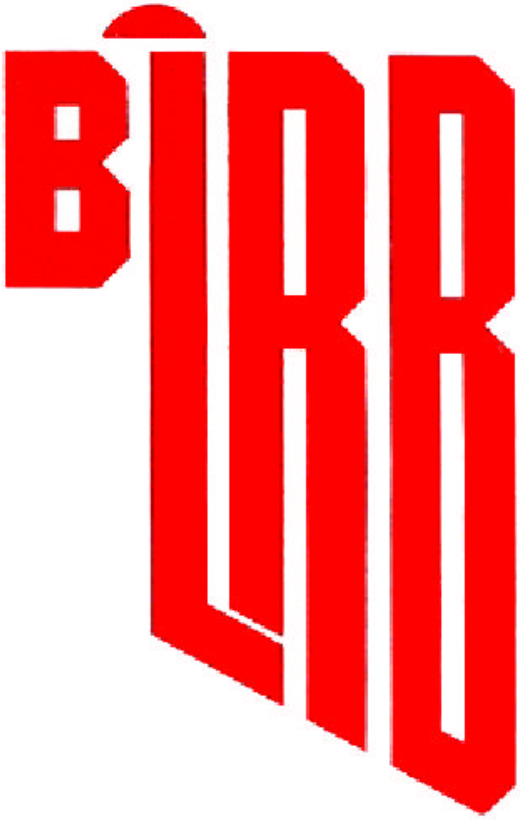

RECOMMENDED GOOD PRACTICE

INSTRUMENTATION CHECKLIST AND CLASSIFICATION GUIDE FOR INSTRUMENTS AND CONTROL SYSTEMS USED IN THE OPERATION OF BLACK LIQUOR RECOVERY BOILERS

THE BLACK LIQUOR RECOVERY BOILER ADVISORY COMMITTEE

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CHANGES

Revised Chapter 1 to recommend functional testing whenever modifications are made to recovery boiler instrumentation or control systems.

Added definitions for “Functional Test” and “Modifications” in Chapter 2.

Added Section 3.13, Functional Testing.

CHAPTER 1 PURPOSE AND SCOPE

The purpose of this Recommended Good Practice is to provide guidelines for the design, installation, and operation of Recovery Boiler controls and Safety Instrumented Systems (SIS) to contribute to operating safety.

No recommendations can be promulgated which will guarantee the elimination of furnace explosions. Technology in this area is under continuous development and will be reflected in later revisions to these recommendations.

These recommendations are based upon the present state of the art and therefore may not be applicable in its entirety to older designs and installations. It is recognized that the number of operating personnel, proximity of operator controls to the recovery boiler, whether a remote control room is provided, etc., may influence the requirements for other instruments or instrumented control systems. Accordingly, it is recommended that the operating companies review this Recommended Good Practice and adopt such features as appear applicable and reasonable for existing installations.

The Black Liquor Recovery Boiler presents challenges of service requirements, operation, fuel burning, reliability, and safety margins. Consequently, the instrumentation selected should be chosen with deliberate discrimination.

The importance of proper maintenance, clean, dry, well regulated air, and a reliable regulated source of electricity cannot be over emphasized. The best of instrumentation becomes meaningless without these essentials.

This Recommended Good Practice is intended as a guide and checklist to provide the proper tools for promoting safety and long term unit availability. It is not intended to specify specific hardware, but to recommend the functions desired for proper operation of the unit.

As used in this Recommended Good Practice the term SHALL is intended to mean required for normal operation and the term SHOULD is intended to mean recommended where applicable.

This Recommended Good Practice includes as one of the tabulated items a Classification Index which determines whether a particular operating mode or technique falls within the following defined scopes:

Classification I	REQUIRED FOR NORMAL OPERATION - Denotes functions necessary for operations.
Classification II	RECOMMENDED WHERE APPLICABLE - The choice may be

at the option of the designer. Its function or equivalent should be provided.

Operator training, maintenance, and carefully established emergency shutdown procedures are recognized as essential to safe operation of Black Liquor Recovery Boilers.

As a basic requirement to assure good practice in the instrumentation and control aspects of recovery boilers, each mill should prepare and maintain instrument and control system documents for each boiler. The documentation should be accurate and complete in every detail, showing location and connections of all instruments and control elements. Relevant operating information should be included. This documentation will provide the basis for system analysis, technical upgrading and hazard evaluation.

All subsequent changes to the system should be authorized by at least the department superintendent or their designee and the documentation shall be upgraded. A hazard evaluation should be made prior to any system changes. Functional testing should be done any time modification work has been performed.

This Recommended Good Practice is an effort to provide documentation of a minimum acceptable industry practice and should not be interpreted in a manner to reduce the level of specific procedures currently practiced by individual operating companies.

CHAPTER 2 TERMS AND DEFINITIONS

Analog: Continuous variable signals or values.

Attemperator: A device to reduce the steam temperature by mixing it with lower temperature steam or water, or by passing it through tubes immersed in water of a boiler drum, generally by means of automatic control. The same as desuperheating.

Auto-manual Control: A control station (or selector station) which permits the operator to select either automatic or manual operation of equipment, can be at a location remote from the actual physical hardware, e.g., the operator may make an adjustment in the control room to change the position of a damper in an air duct hundreds of feet away. The operator may place the control station in the automatic mode and permit a controller to position the damper as required to maintain proper control.

Basic Process Control System (BPCS): (ISA-S84.01 P. 3.1.5) A system that responds to input signals from the equipment under control and/or from an operator and generates output signals that cause the equipment under control to operate in the desired manner. Also referred to as a Process Control System.

CRT: A display device resembling a television used to view items in the control system.

DCS: Distributed Control System - a control system whereby intelligent controllers and associated input/output hardware control different parts of the process, and are interconnected to each other by communication links.

Desuperheat: To reduce the temperature of a gas, i.e., steam to a lower temperature or to its saturation temperature. The saturation temperature is the boiling temperature of a liquid at it's operating pressure.

Digital: Two-state signals or values, i.e., On-Off, High-Low, One-Zero.

Economizer: A tubular heat exchanger following the boiler bank. The boiler feedwater flows through the tubes increasing the water temperature just before it enters the boiler drum. The flue gases give up more of their heat as they pass through the economizer. This reduces the fuel required to produce steam; therefore it is called an economizer.

Evaporator, Cascade: A cylindrical bundle of tubes or plates attached to hubs and rotated by a horizontal axle. The horizontal elements and axle shaft form a wheel much like a paddle wheel, except that the elements provide lower resistance to the black liquor and flue gases. As the wheel rotates, the elements dip into and pass through the black liquor pool in the bottom. The rotation acts like a pump to lift the black liquor out of the pool. The hot flue gases heat the surface film, evaporating the moisture and concentrating

the black liquor. The cascade evaporator is a direct contact evaporator because the hot flue gases directly contact the liquor being evaporated.

Evaporator, Cyclone: An evaporator in the shape of a cylinder in which the flue gases enter tangentially near the bottom and exit at the center of the top. The black liquor is sprayed into the flue gases at the tangential entrance and around the top of the cylinder. The concentrated black liquor flows down the sides of the cyclone cylinder into a funnel and out the bottom. The evaporated moisture is carried out the top with the flue gases. A cyclone evaporator is a direct contact evaporator.

Evaporator, Direct Contact: A heat exchanger (Cascade or Cyclone Evaporators) in which hot flue gases are in direct contact with the black liquor. As the flue gases heat the liquor, water is evaporated. This is used to concentrate the black liquor up to a minimum of 58 percent total solids for firing.

Functional Test: A method of proving all elements of a system operate as designed.

Micro Processor: An intelligent piece of hardware, usually capable of executing only pre-defined programs. It usually cannot store or retrieve data from bulk storage devices.

Modification: A change or alteration that results in a deviation from the original design specifications or criteria.

Monitor: A means of showing (or reminding) the operator of conditions as they occur. A monitor displays a condition or measurement.

Noxious Stack Gas Analyzers: A group of gas analyzers which measure the presence and concentration of objectionable gases which are contained in the flue gases of a recovery boiler. Examples are: TRS (totally reduced sulfur), SO_2 (sulfur dioxide), NOX (Nitrogen Oxides), etc.

Opacity (Smoke, Particulate): The measurement of light transmittance through a duct or stack. By proper calibration methods an opacity meter can measure particulate matter solids suspended in a gas stream, i.e., flue gases. An opacity meter can also measure smoke density, turbidity in liquids, etc. It is basically a means of measuring the loss of light between a light source and a light receiver.

Percent Total Solids in Black Liquor: The percentage of solids by weight in black liquor fluid in the recovery system. For example, if the black liquor is 70% solids, then 30% is water.

Powered Relief Valve: An electrically or pneumatically operated quick opening valve which relieves excess steam pressure. It is generally set at a lower pressure than mechanically (spring) operated relief valves.

Precipitator: A means (usually electrostatic) for collecting dust in the flue gases just before they go up the stack. The flue gases pass through a high voltage electric field and dust particles take on an electrostatic charge. The charged dust particles are then attracted to oppositely charged plates or wire in the chamber. The dust particles attached themselves to the wire where they precipitate into large groups or clumps which are too heavy to be carried by the flue gas stream. These clumps fall into a hopper where they are removed.

Primary Black Liquor Heater: Usually a direct contact heater which injects steam directly into the low temperature black liquor. This heater is normally located on the suction side of the black liquor nozzle pump. Indirect heaters may be used to avoid dilution of the black liquor.

PC: This abbreviation may represent programmable controller, or personal computer, depending on the context of its use. Throughout these recommendations, PC is used to represent programmable controller.

Programmable Logic Controller (PLC): A digital first level control device utilized for sequencing operations which are configured using ladder logic and may have limited analog or continuous control capability.

Record: A measurement that is continuously collected over a given time sample, using a chart recorder or trend log in a DCS system. **NOTE:** The time sample rate selected represents the most accurate record.

Safety Instrumented System (SIS): (ISA-S84.01 P.3.1.53) System composed of sensors, logic solvers, and final control elements for the purpose of taking the process to a safe state when predetermined conditions are violated. Other terms commonly used include Emergency Shutdown Procedure/System (ESP), Safety Shutdown System (SSD), Safety Interlock System and Flame Safety Supervisory System (FSSS).

SAMA Logic: Represents the total control loop philosophy with symbols and a diagramming format. (SAMA- Scientific Apparatus Manufacturers Association).

Secondary Black Liquor Heater: Usually a direct contact heater which injects steam directly into the warm black liquor. This heater is between the discharge of the black liquor nozzle pump and the black liquor spray nozzles in the furnace. Indirect heaters may be used to avoid dilution of the black liquor.

Smelt Bed Camera: A video camera to observe smelt bed and combustion conditions.

Smelt Spout: A trough which drains the molten smelt from the furnace into the dissolving tank. It is cooled to retard spout wastage by molten smelt. Water is commonly used as the cooling medium.

Soot Blower: A device using steam or compressed air for blowing dust, soot and ash from the fire side of the boiler tubes. Most soot blowing systems operate automatically and usually have a sequence control to blow in a specific pattern or arrangement.

CHAPTER 3 GUIDELINES FOR RECOVERY BOILER CONTROL SYSTEMS

3.1 Fail Safe Mode

Fail safe is a designed property of an item which prevents failures from becoming critical failures. A critical failure is one which is likely to cause injury to persons or significant damage to equipment. In process control applications, fail safe refers to the pre-determined safe state each control component reverts to upon loss of motive power or its control.

The change that actuates the particular fail safe mode is an automatic response to an undesirable operating condition and it is not operator initiated.

Final control elements of any material that enters the boiler such as black liquor, auxiliary fuels, air, water, waste streams, etc., shall be fail safe.

Control systems that actuate the combustibles final control element are to be fail safe. The intent is to maintain integrity of applicable BLRBAC firing starting logic and tripping logic schemes.

3.2 Power Sources

Firm power feed is required to the controls, primary elements and operator interface. Firm power is any uninterruptible AC power supply or two independently supplied AC sources not susceptible to the same interruption. Also, each operator's CRT station electronics should have a firm power supply. As a minimum each system should have one (1) redundant power supply per DC bus. The power supplies shall be properly grounded and conditioned in accordance with the manufacturer's specifications and applicable codes.

3.3 Automatic Back-up or Hard Wired

Fail safe design is the first level of protection in preventing critical failures. The next level of protection is the degree of reliability of the process control system. Reliability is the probability that a device will function without failure over a specific time period.

Safe instrumentation practices ensure that the operator can retain control of boiler processes during all operating conditions, including the ability to safely shut down the boiler during control system failures.

The advent of the state-of-the-art control system has resulted in the consolidation of process control loops and motors under the direction of one control system. A failure of the control system could render many control elements inoperable to the operator. The

recognition of failures in the state-of-the-art control system has pointed to the necessity of transfer of control from the faulted unit to a back-up system. Manual control is an operable mode. The transfer to the back-up control may be automatic or initiated by the operator.

The intent of the back up controls is to enhance the reliability of control systems to the extent that failure of one control system component will not render more than one instrument loop or motor control inoperable. This requirement prevents dilution of the present state of reliability inherent in the single loop, single motor controls.

This higher level of reliability in instrumentation applies to those identified control systems as outlined in the applicable BLRBAC publications for promoting safety and the prevention of furnace explosions.

3.4 Critical Loops

Critical loops are control loops that must have a back up. The following are the minimum closed loops identified as critical: Drum Level, ID Fan Control, Fuel Supply (Black Liquor and Auxiliary Fuel), and Air Flow Regulators (Dampers) as applicable.

3.5 Communications

Redundant communications paths shall be required. Each communication path external to the cabinets should be routed separately so that damage to one will not necessarily cause damage to both.

3.6 Man Machine Interface

The operator station must have either at least two video displays, each with its own keyboard and independent set of electronics, or a video display, keyboard and set of electronics with independent digital or analog stations connected directly to the control rack as back-up. Regardless of which alternative is selected, there must be two independent man-machine interfaces, to ensure the operator always has at least one method of control.

3.7 Hardware Jumpers and Software Forces (BYPASSES)

- Operations

  Bypassing of system functions should not be part of normal operating procedures.

- Routine Maintenance

  Routine maintenance that may require temporarily bypassing part of a system

should be planned for in the design. Bypasses to modify the logic, alarms to notify operating personnel and appropriate procedures shall be in place to assure that safe operating conditions are maintained.

- Non-Routine Maintenance

  In order to provide for orderly maintenance of a system, it may be necessary at times to bypass individual functions. This shall be done with the approval of the Recovery Superintendent or the designee. Procedures for performing the maintenance and for notification of operators, maintenance and supervisory personnel should be established and implemented so that safe operations are maintained. Control of this process should be established by an administrative system that identifies when the bypass was installed and when it was removed. The use of a bypass shall be considered a priority condition and repairs shall be initiated in a timely manner.

- Design

  Designing a system to automatically disable an interlock that is not needed during certain operating modes is permitted. For example, a low-pressure switch downstream of the Safety Shutoff Valve (SSV) on a gas system is not part of the system until the SSV has opened.

3.8 System Security

Interlocks, algorithms, alarm points, and other characteristics of critical loops should not be altered intentionally or in error by unauthorized personnel or equipment failure.

It is not possible to define a procedure to guarantee the security of a modern control system. The extensive hardware available along with the flexibility of software does not permit a single set of rules for all installations. These guidelines express the intent, but do not define a detailed procedure.

Each installation shall be selected and installed with “Security” as an important criteria. The user, system supplier, consultant and insurance carrier should all contribute to the decisions governing security.

The control system shall control and monitor the critical loops (including critical motor circuits) while providing the operator with dependable and accurate information. The direct control functions for critical loops shall not be altered by the operator.

Logic changes should only be performed when authorized by the superintendent after his review of the changes with the plant control specialist. Procedures for notification of operators, maintenance and supervisory personnel should be established and implemented

so that safe operations are maintained. A functionality test shall be performed to verify proper operation of the system.

Electronically forcing contacts is not any different than hard wire jumpering of interlocks.

Back-up for software is equally important as backup for hardware. Separate locations should be provided for storage.

a) Consider two mediums:

- Disc
- Tape

b) Consider on-line vs. off-line.

c) Consider comparing and updating the backup to the operating program.

Controlled access, environmentally correct storage should be provided for backup software. Magnetic tapes can deteriorate with time.

Personnel backup is as important as backup for hardware and software. At least two employees should be thoroughly familiar with the system, programming, spares, etc.

3.9 Control System Environment

Hardware shall be installed in atmospheres conducive to promoting longevity of electronic components and consistent with manufacturer's specifications. (Reference applicable ISA documents)

3.10 Approvals

The control system equipment and associated hardware shall be subjected to, and have passed the testing of, at least one approved standards organization such as UL, CSA, ULC, FM, NOC, etc. for use in industrial applications.

3.11 Grounding

The grounding of the control system generally must be kept separate from the equipment and electrical power distribution grounding system. The manufacturer's recommendations should be followed in detail.

3.12 Preventive Maintenance

A preventive maintenance system should be established for all instruments associated with the recovery boiler. A program should identify inspection tasks, inspection frequency, and reporting procedures necessary to schedule, track, and document individual instrument devices.

Documentation shall include the following information as a minimum:

- date of inspection,
- name of the person who performed the test or inspection,
- serial number or other unique identifier of equipment,
- results of inspection/test (design, "as-found" and "as-left" conditions) and
- Inspector comments on overall integrity of inspected system.

A procedure should be used for maintaining, testing and repairing a system.

3.13 Functional Testing

Functional testing of safety instrumented systems is intended to provide the recovery boiler owners and operators with confidence that the system will operate as designed. Functional testing should be conducted within the scope and frequency outlined in the following recommended good practices: Emergency Shutdown Procedures, Safe Firing of Auxiliary Fuels, Safe Firing of Black Liquor and Thermal Oxidation of Waste Streams. Functional Logic test plans should be developed for each boiler based on the starting permissive and tripping interlock block diagrams from the recommended good practices referenced above. Functional testing should be done any time a modification or work has been performed on a safety instrumented system that might reasonably affects its integrity. All testing should be documented and dated with detailed records maintained on file.

Functional testing should verify that the safety systems field devices, wiring, hardware and logic are in sound conditions (i.e. no jumpers, bridges or forces in place, no plugged sensing lines, no broken actuators nor stuck valves or dampers, no damaged instruments nor burnt or corroded wiring, no inadvertent undocumented and/or improper software changes, etc..)

A "complete" trip/interlock test incorporates a signal test from the sensing line (or initiating device for manual trips) through all associated circuitry and logic, and includes actuation of the final elements (valves, pumps, dampers, etc.) being interlocked. It should create or simulate, as safely as possible, the actual conditions being monitored at the sensing lines.

Note: Provided that a complete test through a common output (e.g. MFT) is performed, a test of the remaining individual trip conditions, to just that common output, is acceptable.

While boiler start up, following a shutdown, provides the most feasible time for these tests, it is perfectly acceptable to conduct such tests throughout the year, when possible. This would be applicable for auxiliary fuel and waste stream systems and possibly others depending on operating arrangements of the unit. Any unscheduled trips occurring during boiler start-up or operation may be applied toward meeting the intent of testing for that particular trip or permissive, provided the event is properly documented and the first out system is provided verifies the source of the trip.

CHAPTER 4 GUIDELINES FOR USING A SAFETY INSTRUMENTED SYSTEM

Safety Instrumented Systems are provided to interrupt a process and initiate a pre-determined safe response in the event of an unsafe condition.

The system scope includes sensors, logic, final devices, interconnections and interfaces to other systems. Logic may be performed in an electrical, electronic or programmable electronic system. Technologies include:

- electronic relays and timers
- solid state logic types
- programmable electronic systems
- motor driven timers
- solid state relays and timers
- hard wired logic
- combinations of the above

Initiation may be manual, semi-automatic, or automatic. Applications include:

- ESP, Rapid Drain
- Safe Firing of Black Liquor
- Safe Firing of Auxiliary Fuel

4.1 General Recommendations

These recommendations are in addition to specific recommendations outlined in all other BLRBAC Recommended Good Practices.

1. The SIS shall be optimized for fault detection within the limits of the applied technology and all detected faults shall provide operator notification of a fault occurrence. This includes communication gateways.

2. System failures must result in outputs faulting to and maintaining predetermined fail safe operations.

3. System program protection shall be provided, such as key lock or password, to protect the system from unauthorized access.

4. On-line logic modifications of a SIS are not permitted.

5. A written procedure/checklist should be used for maintaining, functionally testing, and repairing a SIS. The entire SIS should be functionally tested including the sensor(s), the logic solver, and the final element(s).

6. System memory shall be non-volatile or battery backed (memory will retain program instructions on loss of system power). The memory will maintain information for at least seven days on the loss of power.

7. Changes of state in the field elements shall be available to the logic in a SIS in one second or less.

8. The elapsed time from logic realization of an operator command or trip condition to initiation of field action shall be two seconds or less. This is exclusive of input signal filtering.

9. Any SIS used for ESP and/or safe firing of fuels shall not be subject to a shared single fault failure with other control and SIS.

10. It is acceptable for control systems and SIS to share common Man Machine Interfaces.

11. Operator indications of the field device functions shall be based on field device positive feedback.

4.2 Safety Instrumented Systems Applied to ESP

1. Redundant methods or processors should be utilized to insure a timely ESP when initiated by the operator.

2. No single failure should cause or prevent an ESP occurrence.

3. Redundancy designs should incorporate “bumpless” transfer that does not cause an improper ESP action.

4. Backup processors and auto transfer should be tested preferably twice a year, but, as an absolute minimum once per year for operational integrity.

5. System designs should allow for repair of failed components without upset to boiler operations.

6. Faults in backup processors should disable transfer until faults are corrected.

7. If a digital control system is utilized for initiation of an ESP, an alternate entry point to the ESP system should be provided to initiate an ESP. Redundant communication networks are acceptable.

8. It is recommended that the SIS should not rely on continuous power to retain logic states for the ESP system.

9. When a rapid drain system utilizes a UPS system as a back-up power source, time delay functions should be allowed only when the UPS system is providing power to the drain valves. These time delays are for the purpose of minimizing the in-rush current demand placed on the UPS system and shall not significantly delay an ESP.

4.3 Safety Instrumented Systems Applied to Burner Management

1. The use of a SIS for Burner Management on a recovery boiler shall conform to the requirements of the appropriate standards committee such as BLRBAC, FM, NFPA, UL, etc.

2. A master fuel trip relay shall be provided in the system and be functional to operate from commands of the SIS and a dedicated hardwired master fuel trip switch accessible to the boiler operator.

3. First out trip sequence indication shall be incorporated in the system design.

APPENDIX A INSTALLATION CHECKLIST AND CLASSIFICATION GUIDE FOR INSTRUMENTS AND CONTROLS USED IN THE OPERATION OF BLACK LIQUOR RECOVERY BOILERS

In addition to the instruments and controls listed in the following sections, there is a need to establish proper practices for the design, installation and operation of black liquor firing systems for promoting safety and, in particular, prevention of furnace explosions from the introduction of low solids black liquor and/or water into the furnace. Specific recommendations for these systems should be obtained from the Recommended Good Practices as issued by the Black Liquor Recovery Boiler Advisory Committee.

A. FEEDWATER AND STEAM SYSTEMS

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
1.	Drum level control	Maintain drum level by control of feedwater flow for stable & safe operation	Auto-Manual control	X		3 element feedwater control systems are generally preferred for better performance. Separate taps are required for each level measurement.
2.	Drum level	Drum level monitor with safety back-up independent of drum level control	Record Indicate, 2 required High level alarm Low level alarm High level - Master fuel trip Low level - Master fuel trip, 2 required	X X X X X	 X 	Back-up protection. It is recommended that direct connected instruments which contain process fluids should not be piped to the Control Room. Separate taps are required for each level instrument.
3.	Drum level gauge glass	Indication of drum level	Indicate(Local)	X		A gauge glass level must be visible at the steam drum.
4.	Steam flow	Part of drum level control system and used to determine load on boiler Steam Flow <30% (Liquor Firing Only)	Record Indicate Integrate Master Fuel Trip	X X	 X X 	Essential operational data and useful for efficiency check. Comparison of steam and water flow to detect pressure part leaks. Soot-blower steam flow may have to be incorporated into total steam flow. Refer to "Recommended Practice for Safe Firing of Black Liquor" and "Recommended Practice for Safe Firing of Auxiliary Fuels" for application.
5.	Feedwater flow	Part of drum level control system	Record Indicate Integrate	X X 	 X	Essential operational data & useful for efficiency check.
6.	Feedwater Quality	Monitor water quality to the boiler Conductivity pH Dissolved Oxygen Content	 Indicate Record Alarm Indicate Indicate	 X X X 	 X X	Required if not a part of feedwater preparation & condensate return control systems. Integrity of freshwater supply must be assured.
7.	Feedwater supply header pressure	Indicate feedwater pressure available	Indicate Record Low-Pressure Alarm	X X	 X 	
8.	Feedwater supply temperature	Indicate feedwater temperature	Indicate Record		X X	Monitors feedwater heater and condensate systems.
9.	Feedwater pump pressure control.	Means for control of feedwater supply pressure	Control of: -Variable Speed Pumps -Number of Pumps -Pressure Control Valve		 X X X	Separate taps are required for each control.
10.	Feedwater pump(s) tripped	Monitor feedwater pump operation	Alarm	X		
11.	Economizer (if used) water outlet temperature	Fluid temperature and operating guide	Indicate Record		X X	Detects economizer plugging.
12.	Deaerator level low	Monitor deaerator level low	Alarm	X		
13.	Deaerator pressure low	Monitor deaerator pressure low	Alarm	X		

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

A. FEEDWATER AND STEAM SYSTEMS

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
14.	Primary superheater outlet temperature (if used with attemperator or desuperheater)	Measure steam temperature leaving primary superheater	Record		X	Provides warning of abnormal temperatures.
			Indicate	X		
			High Temperature Alarm		X	
15.	Attemperator or desuper-heater outlet steam temperature	Measure steam temperature.	Record		X	
			Indicate		X	
16.	Superheated outlet steam temperature	Measure final steam temperature	Record	X		Provides warning of abnormal temperatures to prevent damage to turbines.
			Indicate	X		
			High Temperature Alarm	X		
			Low Temperature Alarm	X		
17.	Interstage attemperator or desuperheater temperature control (if used)	Control final steam temperature under varying load or firing conditions	Auto-Manual control	X		To prevent spray water from possible entry into furnace or external steam equipment (turbines, etc.) during ESP.
			Trip off water spray with ESP	X		
18.	Attemperator or desuperheater water flow (if used)	Measure spray water flow	Record		X	
			Indicate		X	
			Integrate		X	
			High Flow Alarms		X	
19.	Steam pressure at superheater outlet	Measure steam pressure	Auto-Manual Control		X	
			Record		X	
			Indicate	X		
20.	Steam drum pressure	Measure steam pressure & provide essential operating guide	Record		X	
			Indicate	X		
21.	Powered vent valve (relief valve)	Relieve excess pressure. Control pressure and steam flow during startup	Auto-Manual		X	Establish flow through superheater, reduce safety valve maintenance, & relieve pressure following an ESP.
			Open on ESP (after 8 ft level on rapid drain)	X		
			Indicate Open	X		
22.	Superheater and steam drum metal temperature	Monitor tube temperature during startup and operation	Indicate		X	Metal temperatures may be monitored by individual tube metal measurement or by superheater inlet gas temperature.
			Record		X	
			High Temperature Alarm (Superheater Only)		X	
23.	Metal temperature monitors for emergency drain	Monitor hearth tube metal temperatures below the 8 foot level during an emergency shutdown and drain.	Indicate		X	Recording and indicating of metal temperatures is required only during periods of abnormal conditions.
			Record	X		
24.	Water wall metal temperatures	Monitor metal temperature of water wall tubes	Indicate		X	
			Record		X	
25.	Mill condensate return(s) conductivity	Monitor conductivity of mill condensate return	High Conductivity Alarm	X		
26.	ESP System Drain Valves		Indicate Open	X		Refer to ESP Good Practice
			Indicate Closed		X	
27.	ESP System Stop Valves		Indicate Open		X	Refer to valves required under ESP Good Practice
			Indicate Closed	X		

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

B. COMBUSTION AIR CONTROL SYSTEMS

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
1.	Forced draft control	Maintain constant discharge pressure or control combustion air flow.	Auto-Manual	X		Fan damper or fan speed control.
2.	FD fan(s) discharge pressure.	Indicate combustion air pressure available.	Indicate		X	For trips refer to Auxiliary Fuel Good Practice.
			Record		X	
			Low Pressure Alarm		X	
			Master Fuel Trip if validating FD fan running	X		
3.	Combustion air flow & control	Measure & control combustion air flow including primary, secondary, and tertiary (or higher, if used) ratios.	Auto-Manual	X		Low air flow is 30% of normal air flow at rated load. Quantity and location of flow measuring devices depends on boiler design.
			Indicate	X		
			Record	X		
			Low Flow Interlock & Master Fuel Trips	X		
			Low Flow Alarm	X		
4.	Oxygen	Measure combustion efficiency & detect furnace blackout.	Indicate	X		See “Recommended Good Practice Safe Firing of Auxiliary Fuel in Black Liquor Recovery Boilers”.
			Record	X		
			Alarm Oxygen Low	X		
			Alarm Oxygen High		X	
5.	Combustibles/CO	Measure combustion efficiency and detect furnace blackout	Indicate		X	
			Record		X	
			Alarm Combustibles High		X	
6.	Combustion air temperature	Measure combustion air temperatures.	Indicate	X		Aid to minimizing operating problems due to cold combustion air.
			Record		X	
			Alarm		X	
7.	Air heater outlet pressure	Measure combustion air pressure available.	Indicate		X	Detects pressure drop across air heater in conjunction with FD fan pressure.
8.	Secondary air duct pressure	Measure secondary air pressure.	Indicate	X		Aids in detecting plugged ports.
			Alarm		X	
9.	Primary air duct(s) pressure	Measure primary air pressure.	Indicate	X		Aids in detecting plugged ports.
			Alarm		X	
10.	Tertiary, or higher, air duct pressure (if used)	Measure tertiary (or higher) air pressure.	Indicate	X		Aids in detecting plugged ports
			Alarm		X	
11.	FD fan failure	Monitors FD fan operation.	Alarm	X		Essential to operating safety. See “Recommended Good Practice Safe Firing of Auxiliary Fuel in Black Liquor Recovery Boilers”.
			Master Fuel Trip (If below liquor guns)	X		
12.	Direct-fired air-heater temperature	Monitor direct fired air-heater temperature.	Indicate	X		
			High Temperature Alarm	X		
			Low Temperature Alarm	X		

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

C. FURNACE DRAFT SYSTEM

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
1.	Furnace draft control	Control furnace draft.	Auto-manual	X		Provide essential operating control.
2.	Furnace pressure	Measures furnace pressure.	Indicate	X		See "Recommended Good Practice Safe Firing of Auxiliary Fuel in Black Liquor Recovery Boilers."
			High Pressure Alarm	X		
			High Pressure Master Fuel Trip	X		
			Record		X	
			Low Pressure Alarm	X		
			Low Pressure Master Fuel Trip (If required by furnace or system design)	X		
3.	Boiler draft	Measures draft loss across various sections of boiler.	Indicate	X		Detects plugging in boiler. Quantity & location of indicators depend on boiler design.
4.	Boiler outlet gas temperature	Measure outlet gas temperature.	Indicate	X		
			Record	X		
5.	Economizer outlet gas temperature or direct contact evaporator inlet gas temperature.	Measures gas temperature to the direct contact evaporator (if used).	Indicate	X		
			Record	X		
6.	Direct contact evaporator outlet gas temperature.	Measures gas temperature at direct contact evaporator outlet (if used).	Indicate	X		See also Items D1 & D2.
			Record		X	
7.	Direct contact evaporator inlet & outlet draft	Measures draft at inlet and outlet of direct contact evaporator (if used).	Indicate	X		Detects plugging in the direct contact evaporator.
8.	ID fan failure	Monitors ID fan operation.	Alarm	X		Essential to operating safety. Loss of <u>all</u> ID fans requires Master Fuel Trip and FD Fan(s) Trip.
			Master Fuel Trip	X		
			FD Fan Trip	X		
9.	ID fan discharge pressure	Measures ID fan discharge pressure	Indicate		X	Detects plugging downstream of ID fan.
10.	Stack temperature	Measures temperature of gases at the stack.	Indicate		X	
			Record		X	
11.	Instrument air pressure low	Monitor instrument air pressure.	Alarm	X		

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

D. FIRE PROTECTION SYSTEM

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
1.	Direct contact evaporator temperature	Warns of high temperature and activates fire protection	High Temperature Alarm High High Temperature Alarm High High Temperature Master Fuel Trip High High Temperature Admit Smothering Media	**X** **X** **X** **X**		Refer to BLRBAC “Recommend Good Practice Fire Protection in Direct Contact Evaporators and Associated Equipment.”
2.	Precipitator outlet temperature	Warns of high temperature and activates fire protection	High Temperature Alarm High High Temperature Alarm High High Temperature Master Fuel Trip High High Temperature Admit Smothering Media	**X** **X** **X**	**X**	Refer to BLRBAC “Recommend Good Practice Fire Protection in Direct Contact Evaporators and Associated Equipment” and "Recommended Good Practice for Safe Firing of Auxiliary Fuel"

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

E. BOILER CLEANING SYSTEM

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
1.	Soot blower controls	Keep firesides clean.	Control System Failure Alarm		**X**	Avoid damage due to hand lancing. Save manpower.
2.	Automatic soot blower blowing sequence control	Continuous blowing on set pattern.	Auto-Manual Control		**X**	Free operator for other duties. Tripping of soot blower steam insures against possibility of water entering furnace under or during adverse conditions.
			Forward-Reverse Indicators		**X**	
			Low Steam Pressure Alarm & Interlock		**X**	
			Trip Steam & Retract on ESP	**X**		
			Trip Steam & Retract on MFT	**X**		
3.	Soot blower steam flow	Measures steam flow to soot blower.	Indicate	**X**		Operating data. Soot blower steam flow may have to be incorporated as a part of the drum level control. High alarm indicates soot blower lance failure.
			Record		**X**	
			Integrate		**X**	
			High Flow Alarm		**X**	

F. SMELT SPOUT COOLING SYSTEM

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
1.	Cooling water supply pressure.	Indicates cooling water available.	Indicate Record Alarm Low		**X** **X** **X**	Loss of cooling water can result in spout failure.
2.	Cooling water temperature at spout outlet	Provides warning of cooling water temperature problems.	Indicate (Local) Record High Temperature Alarm	**X** **X**	 **X** 	
3.	Cooling water flow	Indicate adequate flow of cooling water.	Indicate (Local) Record Minimum Flow Alarm	**X** **X**	 **X** 	Equip each smelt spout with individual visual indicator or flow indicator
4.	Cooling water supply tank level control (if tank used)	Maintain proper water level.	Auto-Manual Control Low Level Alarm Indicate	**X** **X** **X**	 	
5.	Loss of any smelt spout cooling water pump	Provide warning of loss of operating spout cooling water pump	Alarm	**X**		
6.	Emergency spout cooling water makeup on	Backup to primary cooling system	Auto-Manual Control Alarm	**X** **X**	 	
7.	Cooling water conductivity high	Monitor cooling water conductivity	Alarm		**X**	

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

G. BLACK LIQUOR AND GREEN LIQUOR SYSTEMS

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
1.	Heavy black liquor storage tank level (includes oxidizer & concentrator surge tanks where used)	Continuous tank level measurement	Record		X	Essential indication of fuel supply.
			Indicate	X		
			Low Level Alarm		X	
			High Level Alarm		X	
2.	Heavy black liquor storage tank temperature	Continuous liquor temperature measurement.	Indicate		X	Monitors pumping capability of heavy liquor.
3.	Precipitator liquor level control (if wet bottom) or ash tank level (if used with dry bottom)	Maintain proper liquor level.	Auto-Manual Control	X		Essential to operations in maintaining fuel supply. In some cases, where weirs are used, instruments may not be required.
			Record		X	
			Indicate	X		
			Low Level Alarm		X	
			High Level Alarm		X	
4.	Precipitator dust removal system failure	Monitor precipitator dust removal system operation.	Alarm		X	
5.	Cascade evaporator level control (if cascade is used)	Maintain black liquor level.	Auto-Manual Control	X		Essential to operation in maintaining fuel supply. Where weirs are used, level control instruments may not be required.
			Record		X	
			Indicate	X		
			Low Level Alarm	X		
			High Level Alarm		X	
6.	Cyclone evaporator sump level control (if cyclone is used)	Maintain black liquor level.	Auto-Manual Control	X		Aids in fire protection.
			Record		X	
			Indicate	X		
			Low Level Alarm	X		
			High Level Alarm		X	
7.	Cyclone evaporator wall wash pressure control	Maintain black liquor pressure to ensure adequate nozzle flow.	Auto-Manual Control	X		Essential to operation. Aids in fire protection.
			Indicate	X		
			Low Pressure Alarm	X		
8.	Primary black liquor heater temperature control	Maintain black liquor at efficient pumping temperature.	Auto-Manual Control	X		Essential to operation. Temperature must be maintained within close operating range. High temperature can cause flashing in fuel supply pump and tank.
			Record		X	
			Indicate	X		
			High Temperature Alarm		X	
			Trip Steam Supply on ESP	X		
9.	Salt cake mix tank level (if used)	Maintain salt cake mix tank level.	Auto-Manual Control		X	Indicates plugged screen or loss of liquor supply.
			Indicate		X	
			Record	X		
			Low Level Alarm	X		
10.	Secondary black liquor heater temperature control	Maintain black liquor at optimum temperature for burning.	Auto-Manual Control	X		Essential to operation. Nozzle feed liquor temperature must be maintained within close operating range. Assists in stabilizing operating conditions and maintaining low levels of total reduced sulfur and sulfur dioxide.
			Record		X	
			Indicate	X		
			Low Temperature Alarm	X		
			High Temperature Alarm		X	
			Trip Steam Supply on ESP	X		
11.	Black liquor strainer drive(s) stopped	Monitor black liquor strainer drive operation.	Alarm		X	

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

G. BLACK LIQUOR AND GREEN LIQUOR SYSTEMS

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
12.	Black liquor mix tank(s) agitator drive(s) stopped	Monitor black liquor agitator drive operation.	Alarm	X		
13.	Black liquor to furnace	Control black liquor flow to furnace.	Auto-Manual Control	X		Essential to operation in maintaining and controlling furnace load. Assists in stabilizing operating conditions and maintaining low levels of total reduced sulfur & sulfur dioxide. Refer to "Recommended Practice for Safe Firing of Black Liquor" and "Recommended Practice for Safe Firing of Auxiliary Fuel" for application.
			Record		X	
			Indicate	X		
			Integrate		X	
		Liquor Header Flow 25% or greater.	Liquor Header Purge Permissive	X		
		Liquor Header Flow <30% (Liquor Firing Only)	Master Fuel Trip	X		
14.	Black liquor supply pump(s) stopped	Monitor black liquor supply (pumps) operation.	Alarm	X		
15.	Black liquor nozzle pump(s) stopped	Monitor black liquor nozzle pump operation.	Alarm	X		
			Divert Interlock	X		
16.	Black liquor nozzle supply pressure low	Monitor black liquor nozzle pressure low.	Alarm	X		
			Liquor Header Purge Permissive	X		
17.	Black liquor nozzle temperature low	Monitor black liquor nozzle temperature low.	Alarm	X		
			Liquor Header Purge Permissive	X		
18.	Black liquor nozzle temperature high	Monitor black liquor nozzle temperature high.	Alarm		X	
19.	Black liquor oscillator(s) drive failure	Monitor black liquor oscillator drive operation.	Alarm		X	
20.	Black liquor percent solids 2 refractometers required	Monitor black liquor solids content to furnace spray nozzle. Essential to safe operation.	Indicate	X		Better solids control helps reduce blackouts. Insures against admitting weak liquor into furnace. (See BLRBAC "Recommended Good Practice Safe Firing of Black Liquor in Black Liquor Recovery Boilers" - Chapter 4).
			Record	X		
			Alarm on minimum 60% Black Liquor Solids	X		
			Automatic Liquor Diversion on low solids, minimum 58%	X		
			Alarm (Audible and Visible) on deviation between two devices >2%	X		
			Refractometer Inoperative/Malfunction Alarm	X		
21.	Black Liquor Gun Position Interlock (one or more)	Prove liquor guns out of furnace	Permissive Interlock	X		
			Indicate	X		
22.	Black Liquor Header valve shut & Divert valve open	Prove liquor isolated from furnace	Indicate	X		
22.a	Black Liquor Header Recirculation valve open	Prove open in preparation for Black Liquor Header Purge	Indicate	X		
23.	Black Liquor Header Purge		Purge in Process-Indicate	X		
			Purge Complete-Indicate	X		
24.	Non-operating Water Sources Open	Prevent introduction of water into furnace	Interlock	X		
			Indicate	X		

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

G. BLACK LIQUOR AND GREEN LIQUOR SYSTEMS

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
25.	Black Liquor Header Wash System Switch in Wash Position	Establish conditions are safe to initiate a ring header wash	Interlock Indicate	X X		
26.	Manual Black Liquor Trip		Indicate	X		
27.	Smelt bed camera	Monitor smelt bed	Indicate		X	Monitors smelt bed condition & aids in avoiding blackouts.
28.	Direct contact evaporator density control	Controls dilution source to direct contact evaporator sump.	Auto-Manual High-Density Alarm		X X	Detect evaporator dilution.
29.	Direct contact evaporator dilution flow control	Controls and monitors dilution source flow to direct contact evaporator sump.	Auto-Manual Indicate	 X	X	
30.	Direct contact evaporator drive(s) stopped	Monitor evaporator drive operation.	Alarm	X		
31.	Direct contact evaporator circulating pump(s) stopped	Monitor circulating pump(s) operation.	Alarm	X		
32.	Dissolving tank level control (if used)	Maintain adequate green liquor level in smelt dissolving tank. Essential to operation.	Auto-Manual Control Record Indicate High Level Alarm Low Level Alarm	X X X	 X X 	Dissolving tank pumps should have suction located at minimum safe level to prevent draining of tank in event of control failure. Depending upon system design, some instruments may not be required.
33.	Dissolving tank temperature	Continuous temperature measurement.	Record Indicate	 	X X	Aid manual operation of green liquor density control.
34.	Green liquor density control	Control dilution to dissolving tank and maintain optimum and uniform green liquor density.	Auto-Manual Control Indicate Record Alarm-High Alarm-Low	X X X 	 X X	Aid to recausticizing operations. Regulates proper pumping controls.
35.	Dissolving tank agitator malfunction.	Monitor dissolving tank agitator current.	Alarm-Low Alarm-High	X X		Indication of mechanical failure. Indication of high density.
36.	Green liquor transfer pumps stopped	Monitor green liquor transfer pump(s) operation.	Alarm		X	
37.	Green liquor recirculation pumps stopped	Monitor green liquor recirculation pump(s) operation.	Alarm		X	
38.	Salt cake feed system failure	Monitor salt cake feed system operation.	Alarm		X	

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

H. FLUE GAS EMISSIONS

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
1.	Flue gas particulates, concentration or opacity	Monitor solids emission or smoke density.	Indicate Record Alarm		**X** **X** **X**	Air quality & efficiency control.
2.	Flue gas analyzer for noxious stack gases	Monitors gaseous emissions including reduced sulfur, sulfur dioxide, nitrous oxides, etc.	Indicate Record Alarm		**X** **X** **X**	Air quality & efficiency control.
3.	Precipitator power failure	Monitor precipitator power operations.	Alarm		**X**	
4.	Precipitator insulator compartment fan failure	Monitor precipitator insulator compartment fan failure.	Alarm		**X**	

I. AUXILIARY FUEL AND BURNER SYSTEM

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
1.	Purge Progress		Indicate	X		
			Interlock	X		
2.	Purge Complete		Indicate	X		
			Interlock	X		
3.	Individual Burner Tripped		Alarm	X		
			Interlock	X		Refer to Auxiliary Fuel document Chapter 5.
4.	Individual Burner Valves Closed		Indicate	X		
			Interlock	X		Applies to Automatic Burner Safety Shutoff Valves
5.	Purge Credit Lost (Master Fuel Trip)		Alarm	X		
			Interlock	X		
6.	Main Header and Main Igniter Safety Shutoff Valves Closed		Indicate	X		
			Interlock	X		
7.	Failure of Auxiliary Fuel Trip Valve to Close (MHSSV, IHSSV, BHSSV, BSSV, RSSV)		Alarm	X		
			Interlock	X		
8.	Individual Igniter or Burner Flame Failure		Alarm	X		
			Interlock	X		
9.	Fuel-Gas Pressure		High Pressure Alarm	X		
			Low Pressure Alarm	X		
			High Pressure Interlock	X		
			Low Pressure Interlock	X		
10.	Fuel-Oil Pressure		High Pressure Alarm	X		
			Low Pressure Alarm	X		
			High Pressure Interlock	X		
			Low Pressure Interlock	X		
11.	Fuel-oil Temperature		Temperature Low Alarm	X		
			Temperature Low Interlock	X		
			Temperature High Alarm		X	
12.	Burner fuel-oil atomizing medium pressure low		Alarm	X		
			Interlock	X		
13.	Igniter oil-Atomizing medium pressure low		Alarm	X		
			Interlock	X		
14.	Burner system energized		Indicate	X		
			Interlock	X		
15.	Burner airflow low		Alarm	X		
			Interlock	X		
16.	NCG stream isolated from furnace		Indicate	X		
			Interlock	X		
17.	ESP activated		Alarm	X		
			Interlock	X		
18.	Manual actuation Master Fuel Trip		Alarm	X		
			Interlock	X		

Classification I - Required for Normal Operation
Classification II - Recommended Where Applicable

I. AUXILIARY FUEL AND BURNER SYSTEM

	Instrument or Control System	Major Function	Operating Modes or Techniques	I	II	Comments
19.	Manual actuation Auxiliary Fuel Trip		Alarm Interlock	**X** **X**		
20.	Soot Blower water wash spoolpiece		Indicate Start up permissive Interlock	**X** **X**		

Specific recommendations for these systems should be obtained from "Recommended Good Safe Practice Safe Firing of Auxiliary Fuel in Black Liquor Recovery Boilers" issued by the Black Liquor Recovery Boiler Advisory Committee.

APPENDIX B DOCUMENT REVISION HISTORY

April 2002

This document has been revised to provide a consistent format.

The word "Master" has been added as appropriate to "fuel trip" in various items in the instrumentation checklist.

Section G, Black Liquor and Green Liquor Systems: Clarified items 30 and 31 by adding the term "Direct contact."

Section I, Auxiliary Fuel and Burner System: Added item 20, Soot Blower water wash spoolpiece.

(Note: Prior revision history not provided.)