

## How Vaisala K-PATENTS® DD-23 System is Built to Conform to BLRBAC Recommendations

This document describes how **Vaisala K-PATENTS Digital Divert Control System DD-23** is built strictly according to the BLRBAC Recommendation Chapter 4 Recommended Good Practice Safe Firing of Black Liquor in Black Liquor Recovery Boilers. The original document is available also at <http://blrbac.org>

*Note. Vaisala comments are printed in Italics.*

### Chapter 4 refractometer black liquor solids measurement system

#### 4.1. General

The heart of the system for the safe firing of black liquor is the ability to correctly, accurately and reliably measure the solids in the black liquor stream immediately prior to the black liquor guns.

To accomplish this solids measurement, refractometers have proven to be effective for black liquor recovery boiler service. As new techniques in measuring solids are developed and proven, they can be considered.

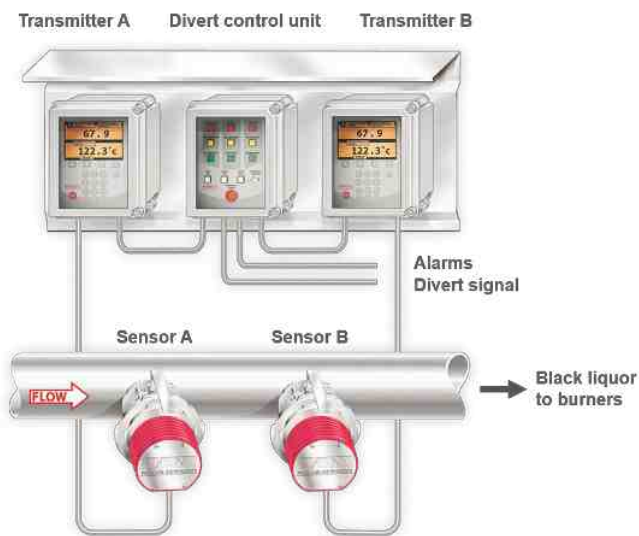


Figure 1. Vaisala K-PATENTS Complete Digital Divert Control System DD-23. The two SAFE-DRIVE™ Refractometers are installed in series.

For the solids measurements, two refractometers in series must be used.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

When both refractometers are in service, the requirement for an automatic black liquor diversion can be satisfied by either of the following options:

1. If either refractometer reads dissolved solids content 58% or below (62% or below if firing >70% solids per guidelines in 6.4 of this document), an automatic black liquor diversion must take place.
2. When both refractometers read dissolved solids content 58% or below (62% or below if firing >70% solids per guidelines in 6.4 of this document), an automatic black liquor diversion must take place.

Either option is satisfactory.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Divert Control System DD-23 is completely digital divert control system and the highest safety rules are satisfied. The rules are listed in decreasing order of security. Only the Rule 1 satisfies the high safety requirements set by BLRBAC, August 1982. On the other hand, the probability of false trips decreases with decreasing safety. It means that, if false trips are too frequent, the Rule 2 may be preferred at the cost of safety. The Rule 2 has later been accepted by BLRBAC.*

*Note: If only one refractometer is in service, removal is prevented at the Vaisala K-PATENTS Digital Divert Control System DD-23 for the sake of maximizing the operational safety.*

*The divert decision rule is selected by the rule switch inside the divert control unit cover. The state of the switch is indicated by an indicator LED for rule #1 and rule #2.*

Rule switch	Rule
1-of-2	Rule # 1
2-of-2	Rule # 2

*Table. Divert decision rule selection in the Vaisala K-PATENTS Divert Control Unit DD-23.*

If the instrument readings disagree on the percent solids by 2% absolute value, an audible and visual alarm must be given.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*If a difference of 2% solids (absolute value) or greater exists between refractometer readings, an alarm shall be activated in the Vaisala K-PATENTS Digital Divert Control Unit DD-23. The alarm limit can be set anywhere between 0-2% solids.*

*Note if two refractometers have different limit values the **lower** value is used as alarm activation in system. Vaisala K-PATENTS Digital Divert Control Unit DD-23 is equipped with relay output for audible alarm signal.*

If one refractometer fails, or is removed from service, black liquor diversion must then be controlled by the remaining in-service instrument; and if this remaining instrument reads 58% or below solids, an automatic black liquor diversion must take place (62% or below solids if firing >70% solids per guidelines in 6.4 of this document). Black liquor shall not be fired if neither refractometer is in service

The refractometers should be part of a specifically integrated system adapted to the black liquor service, and include a system to monitor their operation and indicate trouble or failure of the individual refractometer.

Refractometers used without such a monitoring system can fail unsafe and can give improper and

unsafe dissolved solids readings under certain conditions.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*When only one instrument is IN OPERATION, the diversion takes place if the instrument reads 58% or below. Divert alarm can be set higher than 58%, but never below. If both instruments are out of operation (due to malfunction or maintenance) then according to BLRBAC recommendation diversion must take place.*

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 is an integrated stand alone measurement system adopted to monitor the refractometers operation and indicate trouble or failure of the individual refractometer.*

**Safety decision logics:** *The safety decision logic makes the ultimate decision whether the black liquor can be safely fed to the burner or not. The factors affecting the decision are the number of instruments in operation (none, one or two) and their measurement results. Also the selected divert rule is taken into account when two instruments are in operation.*

**Divert decision logic:** *After the system has evaluated the solid contents to be either safe or unsafe, it decides whether the system should be in the DIVERT state. The default state of the system is the DIVERT state. It can be changed to the NO DIVERT state only by manually pressing the DIVERT RESET push-button when the solid content is sufficient (SAFE SOLIDS). If the solid content drops to UNSAFE, the system drops into the DIVERT state.*

*The only exception to this is when the HEADERWASH is active. In that case the solid content checking is skipped. The system may then be switched between the DIVERT and NO DIVERT states by using the EMERGENCY DIVERT and DIVERT RESET push-buttons in the operator's panel.*

*The system will drop to the DIVERT state in all cases when the EMERGENCY DIVERT button (or its external counterpart) is pressed.*

**In operation logic:** *Whether an instrument is in operation depends on the operator's commands and the instrument's diagnostics. An instrument can be in one of three different states: IN OPERATION, NOT IN OPERATION, and WAIT. When the instrument is IN OPERATION, it is used in deciding whether the solid content is in the safe level. When the instrument is NOT IN OPERATION or WAIT states, it is not used. The WAIT state occurs when the operator has requested*

the instrument to come into operation by pressing the button, but the instrument is in the wash cycle and will come into operation after the wash cycle is completed.

An instrument automatically drops into NOT IN OPERATION if there is a critical malfunction. It may also be dropped by the IN OPERATION button unless it is the only instrument used.

**Malfunction logic:** The MALFUNCTION light is illuminated when the internal diagnostics of either of the two instruments indicates a malfunction or there is a communication timeout to either of the instruments. It should be noted that not all malfunctions are critical malfunctions which drop the instrument from operation.

**Resettable alarm logic:** In order to identify new alarms, there is a resettable alarm logic in the Divert control unit. There are four possible alarm sources: SOLIDS ALARM, SOLIDS WARNING, A&B DIFFERENCE, and MALFUNCTION. The state of the alarm indicator in the operator's panel depends on whether the cause for the alarm is still present. If the cause has cleared (e.g. solids content has risen above the warning limit), the light goes off when the ALARM RESET is pressed. If the cause has not cleared, the light will be steadily illuminated.

**Wash arbitration logic:** The Divert control unit takes care that if there are two instruments in operation, they won't wash at the same time (as that would trip the system). Each instrument controls their own wash cycle. Before the start washing, they request a wash permission from the Divert control unit. If the other instrument is already washing, the unit does not grant this permission until the wash cycle is completed.

Operator's panel functions of the divert control unit are LED indicated. All diagnostic info can be seen in transmitter LCD display also.

The three top rows on the DD-23 operator panel consist of indicator lights (Figure 2). The green A IN OPERATION and B IN OPERATION lights are also push-buttons used to include the refractometers in the Divert system. Below the lights there are push-buttons and the HEADER WASH key used to operate the system.

The indicator lights on the operator panel are arranged like traffic lights: top row is red for alarm, middle row is yellow for warning and bottom row is green for "system ok". When the system is running normally, only the row of green lights should be lit.



Figure 2. Vaisala K-PATENTS DD-23 Operator panel.

The white LIGHT TEST button is used to check that all the LEDs behind the indicator lights are working. It also verifies the data processing system in the control unit. The other two white push buttons, ALARM RESET and DIVERT RESET can be used to reset the system back to normal after all problems have been fixed. The HEADER WASH key enables the use of ring header washing with water, when set to ON. The big red EMERGENCY DIVERT push-button is used to manually initiate divert in an emergency situation. An external push-button can also be connected to a switch input in the control unit

#### 4.2 Refractometer Control System Functions

The refractometer control system shall be capable of performing the following functions:

1. Monitor the positive (+) and negative (-) supply voltage of each refractometer independently. The refractometer's supply voltage shall be maintained within the predetermined minimum and maximum limits for safe operation.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

Each Vaisala K-PATENTS Digital Process Refractometer monitors the supply voltage independently. Monitoring is a part of Vaisala K-PATENTS built-in multi-diagnostics.

2. Monitor the lamp voltage or lamp out of each refractometer independently. The refractometers' lamp voltage must be within the predetermined minimum and maximum limits for safe operation.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Each Vaisala K-PATENTS Digital Process Refractometer monitors the light source (Light Emitting Diode) intensity. (Intensity monitoring gives better diagnostics, than only voltage control). The intensity monitoring is a part of built-in multi-diagnostics. The monitoring is not only limited to checking the light source, but extended to cover complete light path from the light source to the optical image detector. Even the sharpness of the image is monitored. The complete light path monitoring is possible due to digital information handling in the sensor.*

3. Monitor the signal amplitude (if chopper circuit devices are used) of each refractometer independently. Each refractometer's signal amplitude must be maintained within the predetermined minimum and maximum limits for safe operation.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*This requirement applies to analog refractometers, which used chopper motor. The requirement is not applicable to Vaisala K-PATENTS Process Refractometers.*

5. Monitor the liquor temperature at each refractometer's sensing head independently assuring that that each refractometer's liquor temperature is within predetermined minimum and maximum limits for safe operation.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Each Vaisala K-PATENTS Digital Process Refractometer's sensing head monitors not only the liquor temperature, but also the temperature of the electronics by separate board mounted in sensor and transmitter also. Moreover a board-mounted sensor monitors the internal humidity of the sensor head. Minimum and maximum limits for safe operation can be set in the Vaisala K-PATENTS Refractometer. Monitoring is a part of Vaisala K-PATENTS built-in multi-diagnostics.*

5. Monitor the automatic prism cleaning timer system of each refractometer. The sensor output circuit, prior to the hold circuit, should go negative or adequately decrease during the purge cycle.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Each Vaisala K-PATENTS Digital Process Refractometer monitors the measurement signal from the optical image detector. Diagnostics of the optical image are not limited to monitoring output signal prior to hold (as in analog refractometers), but as the complete optical image is verified during the wash cycle. Alarm limits can be set if the image indicates the prism is not completely clean during a wash cycle. Monitoring is a part of Vaisala K-PATENTS built-in multi-diagnostics.*

6. Monitor the automatic prism cleaning timer system to assure that the purge occurs within the predetermined time.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 monitors that the purge occurs within the predetermined time in the each refractometer. The Divert Control Unit synchronizes purges in each refractometer preventing purging off both refractometers simultaneously. Monitoring is a part of Vaisala K-PATENTS built-in multi-diagnostics.*

7. Monitor the cooling water to each refractometer head to assure that cooling water is not lost to a sensing head. If any of these malfunctions (item 1 through 7) occur, the following action shall be initiated:
  - a. An alarm shall be activated, identifying the refractometer and circuit at fault.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*The requirement applies to refractometers, which use cooling water. The requirement is not applicable for Vaisala K-PATENTS Process Refractometers. The maximum continuous process temperature Vaisala K-PATENTS Process Refractometer is 170°C, and no cooling water is required.*

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 activates an alarm, identifying the refractometer and circuit at fault.*

- b. The refractometer shall be electrically removed from the refractometer control system.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 electrically removes the refractometer from the divert control.*

- c. The remaining “good” refractometer shall remain in service.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 keeps the “good” refractometer in service.*

8. Compare the refractometer outputs. If a difference of 2 % (absolute value) solids or greater exists between refractometer readings, an alarm shall be activated.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 monitors each refractometer solids readings. If the absolute difference is 2% or greater, Vaisala K-PATENTS Digital Divert Control Unit DD-23 will activate an alarm.*

*Note: The absolute difference can also be configured smaller than 2% in Vaisala K-PATENTS Digital Divert Control System.*

9. Performs a black liquor diversion, if one of refractometer is removed from service or fails in prism wash, and the remaining refractometer fails or reads a solids of 58% or less.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 will perform a black liquor diversion, if one of refractometer is removed from service or fails in prism wash, and the remaining refractometer fails or reads a solids of 58 % or less.*

*Note: The solids level of 58% can also be configured higher than 58% in Vaisala K-PATENTS Digital Divert Control System. This is feasible for mills, which operate with higher solids level.*

10. Monitor all cables from the refractometer and the components of control system. If any cable is cut or removed, an alarm shall be activated.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 monitors all cables from the refractometer and the components of control system. If any cable is cut or removed Vaisala K-PATENTS Digital Divert Control Unit DD-23 activates an alarm. All communications are digital Ethernet, monitoring is not limited only to check cables, but also that the digital signals are correct with check-sum.*

11. Provide primary alarm or diversion function by a means other than the refractometer indicating meter’s contact.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*The primary alarm and diversion function is provided in Vaisala K-PATENTS Digital Divert Control Unit DD-23.*

12. Have capability to allow the manual removal of either refractometer from service retaining the remaining refractometer in full service for diversion purposes.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Each Vaisala K-PATENTS Digital Process Refractometer can be manually removed and restored from the divert control by pushing “Remove from Divert Control” button in the refractometer and restored by pushing “Restore to Divert Control” button in the refractometer.*

13. Require a manual reset following a black liquor diversion or malfunction of the refractometer control system.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 has a manual reset button. The manual reset button resets the status after a black liquor diversion or malfunction of the refractometer control system.*

14. Monitor the position of sensing head isolation valves. A partially closed or closed valve shall activate an alarm and remove the refractometer from the service.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*The requirement applies to isolation valve designs, which can be partially closed or closed when sensor is installed in the valve, which may create dangerous situations.*

*The requirement is not applicable for Vaisala K-PATENTS Process Refractometers, because the sensor is installed in the process via ball valve design and closing of the valve is mechanically prevented during the sensor insertion.*

15. Initiate a low solids alarm signal from each refractometer at 60% solids or at 70% solids if firing >70% solids per guidelines in 6.4 of this document.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Divert Control Unit DD-23 initiates an alarm signal, if refractometer shows 60% solids or at 70% solids if firing >70% solids per guidelines in 6.4.*

*Note: The solids level warning of 60% can also be configured higher than 60% in Vaisala K-PATENTS Digital Divert Control System. This is feasible for mills, which operate with higher solids level.*

16. Prohibit the simultaneous washing of the individual refractometers.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Control Unit DD-23 synchronizes purges of both refractometers prohibiting the simultaneous washing of the individual refractometers. Monitoring is part of Vaisala K-PATENTS built-in multi-diagnostics.*

17. Require manual restoration of a refractometer, which has been removed, either automatically or manually, from service.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Control Unit DD-23 requires manual restoration of a refractometer, which has been removed either automatically or manually from service.*

*Each Vaisala K-PATENTS Digital Process Refractometer can be restored manually to the divert control by pushing "IN OPERATION" button in the main divert display.*

18. Have provision for manual prism washing.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

Manual prism wash can be activated from each Vaisala K-PATENTS Digital Process Refractometer by pushing "Manual wash" button in the refractometer.

19. Require an automatic switch to single refractometer diversion (for systems set to require both refractometers read low solids to divert – dual refractometer diversion) when one refractometer is in prism wash cycle. An automatic return to chosen dual refractometer diversion will occur after completion of the prism wash cycle.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS Digital Control Unit DD-23 will switch automatically to single refractometer diversion when one refractometer is in wash cycle. System will automatically return to dual refractometer diversion rule (two-of-two rule) after completion of the prism wash cycle.*

*The rule applies for systems set to require both refractometers read low solids to divert – dual refractometer diversion; two-of-two rule. Note: the requirement is implemented in BLRBAC recommendation in October 2000. Vaisala K-PATENTS Digital Divert Control System DD-23 meets this requirement.*

All of the above functions may not apply to all refractometer control systems since some refractometers:

- a. Do not utilize cooling water,
- b. Have sensing heads that are not affected by liquor temperature, etc.,
- c. May have difference in electronic circuitry.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

#### **4.3 Refractometer Control System – Controls & Indicators**

The refractometer system shall be equipped with the following controls and indicators:

1. Reset switch.
2. Switch or other means to manually remove either refractometer from service.
3. Visual solids display for each refractometer.
4. Status lights indicating “in service”, “inoperative” and/or “malfunction” for the individual refractometer and status of diversion valve.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

Operator panel of Vaisala K-PATENTS Digital Divert Control System DD-23 consist of

1. *Reset switch.*
2. *Push button to remove either refractometer from service.*
3. *Graphic Liquid Crystal Display LCD for solids readings of each refractometer.*
4. *Status lights indicating “in service”, “inoperative” and/or “malfunction” for the individual refractometer and status of diversion valve.*

#### 4.4 Refractometer Control System – Alarms and Indicators

The recommended alarms and indicators of the refractometer control system are:

Condition	Audible	Indicator
1. Refractometers reading more than 2% absolute difference	X	X
2. Black liquor solids at or below 58%	X	X
3. Refractometers inoperative and/or malfunction	X	X
4. Black Liquor solids at 60%	X	X
5. Black Liquor solids at or below 62% if firing >70% solids per guidelines in 6.4 of this document	X	X
6. Black Liquor solids at 70% if firing >70% solids per guidelines in 6.4 of this document	X	X

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Operator panel of Vaisala K-PATENTS Digital Divert Control System DD-23 consist of*

1. *Indicator and relay output for 2% solids absolute difference.*
2. *Indicator and relay output for black liquor solids% at 58%.*
3. *Indicator and relay output in operation and relay output for malfunction.*
4. *Indicator and relay output for black liquor solids% at 60%.*
5. *Indicator and relay output for black liquor solids% at 62%.*
6. *Indicator and relay output for black liquor solids% at 70%.*

#### 4.5 Installation Requirements

1. The refractometers shall be installed in series.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Digital SAFE-DRIVE™ Refractometers are installed in series at Vaisala K-PATENTS Digital Divert Control Unit DD-23.*

2. The refractometer sensing heads shall be installed in such a manner that the individual sensing heads can be taken out of service or removed without having to valve off the liquor piping or open bypass valves.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Digital SAFE-DRIVE™ Refractometers are installed in the main process line using SAFE-DRIVE™ Isolation valves. Safety of operation is maximized by SAFE-DRIVE Isolation valve design: all steps are mechanically controlled during the insertion and retraction.*

3. All cabinets, wiring, etc., shall be suitable for the atmosphere and service conditions normal to a recovery boiler installation.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*All cabinets are NEMA 4X in the Vaisala K-PATENTS Digital Divert Control Unit DD-23.*

4. The refractometer sensing heads shall be installed so that they are accessible and readily serviceable.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*The refractometers sensing heads are installed through Vaisala K-PATENTS SAFE-DRIVE™ Isolation valves and sensing heads can be inserted and retracted during process operation pressure.*

5. The refractometer sensing heads may be installed in any position on a vertical pipe run. On a horizontal run of pipe, the sensing heads must be installed on sides of the pipe. The reason for this is to ensure that the prisms are always covered with liquor.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS SAFE-DRIVE™ refractometer sensing heads can be installed into vertical or horizontal pipe runs from 2" up to 20" in the Vaisala K-PATENTS Digital Divert Control Unit DD-23.*

6. The electrical power supply to the refractometer control system shall be from a dependable (stable) source.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Both SAFE-DRIVE™ refractometer indicating transmitters DTR have separate power supplies.*

7. A dependable supply of cooling water of satisfactory capacity must be provided for refractometers requiring sensing head cooling water.
8. Dry oil- free instrument air shall be provided to the refractometer sensing heads to prevent and control condensation in the heads.
9. A steam supply source of sufficient capacity shall be provided to meet flow, and minimum and maximum pressures requirements.

All installation requirements may not apply to all refractometers and refractometer systems.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Not applicable in Vaisala K-PATENTS Digital Divert Control Unit DD-23.*

#### 4.6 Refractometer Problems

The three major causes of refractometer trouble or failure are:

1. Loss of cooling water and its effect on the sensing head.
2. Lack of reliability of the prism wash.
3. Condensation in the sensing head.

These may not apply to all refractometers due to differences in construction and circuitry.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

1. *Not applicable for Vaisala K-PATENTS Process Refractometer.*
2. *Prism wash success is continuously monitored in the Vaisala K-PATENTS SAFE-DRIVE™ Process Refractometer and it is a part of built-in multi-diagnostic system.*
3. *Vaisala K-PATENTS SAFE-DRIVE™ Process Refractometer does not use cooling water. Condensation is eliminated by enclosure sealing (Nema 4X) and with humidity indicator in sensing head.*

#### 4.7 Cooling Water Loss

It is of vital importance that the loss of cooling water be detected. This may be done through a temperature sensing element or flow monitor which shuts down the refractometer involved.

Damage to the sensing element of a refractometer does not occur instantaneously, but it is essential that the system detect abnormal temperatures due to cooling water loss, flow blockage, etc., and that the cooling water be promptly restored.

The individual refractometer manufacturer's instruction and maintenance manuals shall be consulted with reference to: potential damage to the sensing element; identification of a damaged element; how and when to replace a damaged element.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Not applicable for Vaisala K-PATENTS Process Refractometer.*



#### 4.8 Prism Wash

The time interval between prism washes may vary with the black liquor composition. It is recommended that the minimum wash period be 7-10 seconds of wash every 20 minutes. Short duration washes at more frequent intervals are more effective than long washes at long intervals. Ideally, steam pressure for prism washing should be 35 psig above the black liquor pressure, plus the pressure required to open the protective check valve.

Awareness must be maintained of the effect of changes to the prism wash programming variables. Various refractometer systems have the capability to adjust: condensate drain time, steam on time, recovery time and interval between wash time. It may be possible to configure the system to have the total time that both refractometers are in their wash cycle represent a significant percentage of operating time.

If one refractometer is out of service for repairs and the remaining refractometer is in prism wash, black liquor solids are not being monitored. Prism wash should be minimized to that needed to maintain the system.

If high pressure steam is used, it may abrade the prism. If only high pressure steam is available, a reducing valve shall be used. The refractometer prism must have a clear polished optical surface, and if it becomes abraded, it must be replaced. If the prism wash system has not operated properly and the prism becomes coated, it must be removed and properly cleaned.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS SAFE-DRIVE™ Process Refractometer built-in optical image detection (patented) is used to optimize suitable wash times and self-diagnostics for user-friendly and safe operation.*

#### 4.9 Condensation in Sensing Head

Condensate may build up in the refractometer sensing head and if this occurs, the instrument operation will be erratic. The procedure for determining this condition and for the elimination of excessive moisture in the sensing head is not the same for all refractometers. The manufacturer's instruction and maintenance manuals shall be consulted and followed carefully.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*Vaisala K-PATENTS SAFE-DRIVE™ Process Refractometer humidity is measured continuously as part of the built-in multi-diagnostics.*

#### 4.10 Refractometer Calibration

All refractometers shall be calibrated against a reliable periodic test. (See Chapter 6 -Off-Line Black Liquor Solids Measurement)

The refractometer shall be calibrated:

1. On initial installation or reinstallation.
2. At any time it is felt or known that the refractometers may be deviating from the known black liquor solids content.
3. Any time there is a 2% difference between refractometers. The reading of the refractometers shall be checked against the off-line moisture analyzer at two hour intervals (8 hour intervals if firing above 70% solids), and the off-line moisture analyzer shall be checked by the TAPPI method weekly.

All refractometer calibration changes shall be entered in the recovery boiler "log book".

If the continuous solids monitor differs from the field measurement by more than 2% on an absolute basis, the off-line test results must be confirmed and then if required the continuous monitor should be recalibrated.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)

*The calibration of Vaisala K-PATENTS Process Refractometer can be verified with certified refractive index liquids, which have traceability to NIST standard. The instrument verification procedure according ISO 9000 is easy to do with transmitter's menu-guided procedure.*

#### 6.4 General Comments

Field solids measurements should be made at regular, frequent intervals. During start-up and periods of upset, more frequent field testing is recommended.

- Boilers with an as-fired solids less than or equal to 70% BLS:
  - Every two hours is a recommended minimum frequency during normal operation.

- Boilers firing Black Liquor solids greater than 70% BLS:
  - Manually test the black liquor solids a minimum of every eight (8) hours if the following conditions are met:
    - The refractometers must be within 2%.
    - The boiler must be in an established stable firing condition.
    - The weekly TAPPI test procedures must be in agreement with the refractometers.
    - The low solids divert should be increased to 62% BLS.
    - An audible alarm should sound if the solids drop to 70% solids or below.
    - If the Black Liquor solids drop to 70% or below the two hour testing frequency shall be resumed.

All solids measurement methods should be checked against the TAPPI Standard, T650-

om-05, on a regular basis. Once per week is a recommended minimum frequency.

Refractometers do not see suspended solids while direct solids measurements do include them. The liquor composition should be as stable and

representative as possible when taking samples for off-line solids measurement. There should be no deliberate changes in saltcake makeup, or chemical addition when the refractometer is being checked against an off-line measurement.

Source: BLRBAC RECOMMENDED GOOD PRACTICE Safe Firing of Black Liquor in Black Liquor Recovery Boilers (April 2010)



Figure 3. Vaisala K-PATENTS Digital Divert Control System DD-23.

Should you have any questions regarding this document or the Vaisala K-PATENTS Digital Divert Control System DD-23, please contact [www.vaisala.com](http://www.vaisala.com)



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