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Yukon College Biomass Heating System
Concept Design Report

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1 LIST OF ABBREVIATIONS

BC	British Columbia, Canada
^{o}C	Degrees Celcius
CO	Carbon Monoxide
CO_2	Carbon Dioxide
Igal	Imperial Gallon
kW	Kilowatt (one thousand watts)
kWh	Kilowatt-hour
m^2	Square Metres
m^3	Cubic Metres
mg/Nm^3	Milligrams per Normal Cubic Metre of air, where 'normal' is at $20^{o}C$ and atmospheric pressure.
MMBTU	Million British Thermal Units
MW	Megawatt (one million watts)
NOx	Nitrogen Oxides
PM	Particulate Matter
PM10	Particulate Matter 10 microns or less in diameter,
PM2.5	Fine Particulate Matter 2.5 microns or less in diameter
SOx	Sulphur Oxides
VOC	Volatile Organic Compounds
3rd Class	Third Class Engineer's Certificate of Competency
4th Class	Fourth Class Engineer's Certificate of Competency

2 INTRODUCTION

2.1 BACKGROUND

2.1.1 Yukon College History

The Yukon College has had its Whitehorse campus in its present location since June of 1988. The building complex consists of student residences, a gymnasium building, an academics building, a commons building and a trades building. At the East end of the trades building is the energy centre, in which the central heating plant for the entire complex resides.

With the construction of this building complex a fluidized bed gasifier was installed in the energy centre with a biomass feed system used for feeding wood chips. This gasifier has never functioned as designed however, and has not contributed to the building's heating system. Two oil boilers were also installed and the complex has been fuel-oil heated ever since. Eight years later, an electric boiler was added. The latter was put on the secondary sales program, which makes use of excess hydropower at a lower rate. The oil and electric boilers form the campus heating system as it stands today.

With rising costs of fuel oil, the rapidly diminishing supply of secondary power, and the increasing concern over environmental effects of fossil fuel combustion, the Energy Solutions Centre is evaluating the implementation of a wood biomass heating plant to supplement the existing system at the Yukon College.

2.1.2 Previously Completed Studies

A number of studies relating to the Yukon College's gasifier and to biomass systems in the Yukon have been completed, the first two of which are particularly applicable and are referenced throughout this report.

1. (CANMET Report) *Re-Capitalization of Yukon College Gasifier* by CANMET Energy Technology Centre – Ottawa for Yukon Mines Energy and Resources, May 2009
2. (Ventek Report) *Feasibility of and Options for a Public Bioenergy Heating* Systems *Retrofit* by Ventek Energy Systems Inc. for Energy Solutions Centre, Government of Yukon, March 2009.
3. *Supplemental Report on Additional Uses of the Yukon College Gasifier* by Farquhar Resource Consulting Limited, January 2006
4. *Economics Study of Re-Commissioning the Yukon College Fluidized Bed Gasifier* by Farquhar Resource Consulting Limited, November 2005
5. *Technical Evaluation of Yukon College Gasifier* by CANMET Energy Technology Centre – Ottawa, December 2004
6. *Feasibility of Providing a Wood Fueled Boiler at Yukon Community College* by Superior Indoor Climate Engineering, January 1998

2.1.3 Project Goal

FSC Architects & Engineers was retained by the Energy Solutions Centre to complete this concept design report to identify a scope of work for a new biomass heating plant at the Yukon College. The goal of the report is to facilitate design decision-making required to move forward to the next phase of design.

The main objectives of this study are the following:

- Estimate heating plant capacity.
- Determine equipment requirements.
- Determine biomass plant operator requirements.
- Research biomass emission constraints, regulations, and control technology
- Determine implementation costs

2.2 BIOMASS ALTERNATIVE

Biomass fuel sources derive from organic material such as switch grass, straw, and wood. More common biomass fuels in Canada are wood pellets and wood chips. Both fuel sources provide common benefits in comparison to using fuel oil or propane. Some of the benefits to using locally processed wood-chips/wood pellets as a primary source of heat are listed below:

- Biomass makes use of local renewable energy source that is otherwise unused and keeps energy dollars circulating in the local economy[1]
- Wood has a history of less volatile prices, unaffected by global economics and political events, unlike fuel oil, propane, and natural gas
- Biomass systems burn significantly more cleanly than wood stoves as they are precisely controlled and have higher efficiencies
- The cost of biomass fuel is generally less than half the cost of fuel oil on an energy value basis.
- Implementing biomass may stimulate local industry in wood chips or pellets and result in use of local (Yukon) wood products.
- Biomass combustion is carbon neutral: When wood is burned, it recycles carbon that was already in the natural carbon cycle. Consequently, the net effect of burning wood fuel is no new CO_2 is added to the atmosphere.

Fully automated biomass boiler systems operate with computer controls to energize auger conveyors and live bottom floors to convey the material into the boiler system. This type of system eliminates the need for the boiler operator to handle any of the wood fuel. These modern biomass heating systems are comparable to fuel oil and / or propane in such a way that once the boiler is in operation there is minimal supervision required.

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[1] At present, “local” for wood chips is Yukon and for pellets is Northern BC.

3 EXISTING HEATING PLANT

3.1 BOILERS

Located in the back of the Yukon College complex, the energy centre contains the existing heating and cooling plant which is made up of four (4) existing boilers with thermal storage tanks, expansion tanks, recirculation pumps, and a chilled water system.

The Energy Centre's heating plant includes the following boilers:

B1: 2900 kW (10 MMBTU) fluidized bed gasifier, status: non-operational

B2: 4000 kW (13.5 MMBTU) oil fired boiler, status: peaking boiler

B3: 800 kW (2.7 MMBTU) oil fired boiler, status: lead boiler and,

B4: 750 kW (2.6 MMBTU) electric boiler, status: lead boiler on secondary sales.

3.1.1 Gasifier B1

Installed at the building's inception in 1987, this fluidized bed gasifier never operated as originally specified and was taken out of service in 1991.

Since then, numerous studies have been conducted identifying the feasibility and economics of operating it, dismantling it or refurbishing it.

Photo 1: Existing Gasifier B1

Photo 2: Existing oil-fired boiler B2 (during summer maintenance)

3.1.2 Oil Boiler B2

This 1987 Bryan forced draft oil-fired boiler was also installed with the original construction of the building. It's original purpose was as stand-by for the gasifier B1. Presently, it is used as a peaking boiler during extreme temperatures and is otherwise not operated. Despite its age, it appears to have been well maintained and runs smoothly. It is, however, grossly oversized as a peaking boiler and also occupies a large space in the energy centre.

Oversized boilers typically run inefficiently as they are rarely operated at full load where maximum efficiency is attained. Upon start-up in 1987 the boiler performed at 82% efficiency at full fire. It is recommended to conduct another efficiency test on this boiler to determine its actual present-day performance.

3.1.3 Oil Boiler B3

Photo 3: Existing oil-fired boiler B3

Oil boiler B3 is another Bryan boiler dating back to 1987. It is the same as B2 other than its smaller size. Its efficiency upon start-up was 81% at full fire.

3.1.4 Electric Boiler B4

The Caloritech boiler B4 is an electric boiler that runs on secondary power, which is available at the discretion of Yukon Energy Corporation based on available supply of electricity. It is the newest boiler in the energy centre dated 1995 on its nameplate. It provides all of the summer heating load (mainly domestic hot water heating) and is also the primary boiler for winter heating.

Boilers B3 and B4 provide the substantial portion of heating for Yukon College.

Photo 4: Existing electric boiler B4

3.2 HOT WATER HEATING SYSTEMS

3.2.1 Thermal Storage

Three thermal storage tanks, each at 30,000 Igal capacity, are located on the lower level of the energy centre. These tanks store hot water from the boilers, and supply the hot water distribution system.

Currently, the capacity of these thermal storage tanks allow for boiler B2 to be shut down during unsupervised periods (nights) and re-ignited in the daytime without compromising the system’s capability of maintaining the complex’s heating setpoints.

3.2.2 Distribution System

The hot water distribution system includes pumps, expansion tanks, unit heaters, radiant panels, fan coils, heat exchangers and a domestic hot water tank immersion heater.

3.3 BIOFUEL STORAGE AND CONVEYOR

There is an existing underground storage bunker for the gasifier B1 located adjacent to the energy centre (see photo 5 below). It has an approximate capacity of 60m^3 and has a hopper and belt conveyor to deliver the biofuel to the gasifier (see photo 6).

Photo 5: Underground Storage Bunker

Photo 6: Hopper and belt conveyor

4 BIOMASS FUEL SOURCES

For the Yukon, the most practical options for a biomass boiler fuel source are wood briquettes (photo 7), wood chips (photo 9) and wood pellets (photo 8) due to the "2200 square kilometre area of dead forest potentially available for energy use"[2] in the area around Haines Junction, and the relative lack of any other plant source in the territory. At present , there are no briquette manufacturers locally so they are not included in this discussion, however they could potentially be an option in the future.


Photo 7: Wood Briquettes


Photo 8: Wood Pellets


Photo 9: Wood Chips

The availability, advantages and disadvantages of wood pellets and chips are discussed in subsection 3.5.1 of the CANMET report and also in section 5 of the Ventek report. Table 1 summarizes some of the advantages and disadvantages of wood chips and wood pellets for the specific application at Yukon College.

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[2] CANMET Report paragraph 3.5.1 pg. 53

	Wood Pellets	**Wood Chips**
Bunker/Auger Modifications	Not Required	Required
Storage	Relatively compact fuel	Bulky fuel
New storage	Silo – 112 m^3	Bin – 280 m^3
Cost	~$105,000	~$650,000
Cost	$260 - $300/tonne	~$150/tonne
	$0.015/MJ	$0.010/MJ
(at Yukon College)	$375,000 per year	$250,000 per year
Properties	Consistent	Inconsistent
Moisture Content (MC)*	5%	26% green, 12% bug/fire killed
Bulk Density	>600kg/m^3	~200kg/ m^3 at 25% MC
Heating Value	>20MJ/kg	~ 15MJ/kg at 20% MC
Quality	Stable	Varying
Combustion Emissions PM2.5	Lower	Higher
Availability – present day	Imported - Trucked from Prince George area	Sourced locally - Trucked from Whitehorse area or Haines Junction
Availability – future	Possible development of local wood-pelletization plant – based on demand and production cost	Increased demand = increased access to forested areas = increased availability
Present Local Employment	Less Favourable	Favourable
Equipment Maintenance	Lower	Higher

*MC for Yukon wood chips and BC pellets

Table 1: Wood fuel comparison

5 PRELIMINARY HEATING LOAD CALCULATIONS & HEATING PLANT SIZING

5.1 HEATING LOAD

Design heating load for the entire Yukon College complex was estimated based on historical energy consumption data for the past four years. Detailed heat loss calculations for the complex were not performed.

The Yukon College's total energy usage history is fairly consistent but fuel oil appears to be on the rise as indicated by the high volume consumed in the most recent year April 2008-March 2009. Last winter saw a 6% increase in heating degree days, more frequent unavailability of secondary power and consequently more operation of the peaking boiler B2 than in previous years. Energy consumption over the past 4 years is shown in Table 2 below and the calculations made for estimating design load are found in Appendix B.

Year April 1 – March 31	Heating Degree Days[3] (<18°C)	Actual Fuel Oil Litres	Actual Electricity kWh	Total Energy Consumption (X 1000 MJ)	Estimated Design Load kW
2005-06	6373	266,605	3,806,880	27,600	1,800 kW
2006-07	7031	294,030	3,257,760	25,900	1,200 kW
2007-08	6680	392,873	3,043,200	29,300	1,700 kW
2008-09	7204	535,612	2,468,777	31,600	1,600 kW

Table 2: Design load and energy consumption

It is important to note that design load is the "worst case" load seen in a particular heating season and is an indicator used to size heating equipment. The design loads estimated here are based on actual energy consumption. Since in any of these particular years the worst case that the Yukon College will ever see is not necessarily attained, the *peak design load* must be assumed to be greater than the design load estimated here.

The lower design load of 1200 kW in 2006-07 indicates that there were no periods (over 24 hrs) of extremely low temperatures (below -40 °C) however the high number of heating degree-days indicates there were extended periods of low temperatures (-30 to -40 °C). In contrast, the winter of 2007-08 had extremely low temperatures (below -40 °C) but shorter periods of low temperatures (-30 to -40 °C) resulting in a higher design load and lower number of heating degree days. This temperature data has been reviewed in the history as recorded by Environment Canada.

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[3] Source: Environment Canada's National Climate Data and Information Archive www.climate.weatheroffice.ec.gc.ca

5.2 BIOMASS HEATING PLANT SIZING

As noted in subsection 4.2.1 of the Ventek report, it is best to operate the biomass boilers at their peak capacity as much as possible to maintain high efficiency. This applies to all fuel combustion boilers whether they are fossil fuel or biofuel boilers.

Table 2 above shows the greatest design load at 1.8 MW. Assuming that the biomass heating plant is to be sized to meet this load, two biomass boilers each at 50% of the design load of 1.8 MW are required. The optimum size for the biomass boiler plant is 2 x 900 kW boilers. During the shoulder seasons only one of the biomass boilers would run and as the outside temperature drops, the second boiler would come on to maintain indoor comfort.

Assuming that this design load of 1.8 MW is 90% of the *peak design load*, as discussed in the previous subsection, then there is still a requirement for an additional heat source to cover the last 10%. One of the existing boilers, either boiler B3 or boiler B4 or both could remain operational as the peaking boiler. This peaking boiler would only run during periods of extreme heating load or if one of the new biomass boilers were out of service.

6 NEW BIOMASS HEATING PLANT

6.1 OVERALL PLANT

Presently, when heating is required the electric boiler B4 starts up. When it reaches full capacity and more heat is required the small oil boiler B3 starts up. When it reaches full capacity and more heat is required (peak loading) the big oil boiler B2 starts up. In the event that boiler B2 goes down, there is insufficient capacity for peak heating.

With the new biomass heating plant the same sequence will occur, only with different boilers. The B4-B3-B2 sequence would be replaced by BB1-BB2-B4 where BB is biomass boiler. If secondary sales power were unavailable, the sequence would be BB1-BB2-B3. Should any one of the four boilers go down, there would still be sufficient capacity to meet the peak heating load. Boiler B2 would no longer be required. Gasifier B1 is presently unused and would also not be required with the installation of the biomass plant. It may be advantageous to evaluate and consider the removal of gasifier B1 and boiler B2.

6.2 BIOMASS BOILERS & ASSOCIATED EQUIPMENT

To attain the design load of 1.8MW it is recommended that two 900 kW biomass boilers be installed. Photo 10 shows a similar installation in Germany by KÖB, an Austrian company that is owned by Viessmann and in Canada goes by Viessmann-KÖB. These boilers are distributed in BC and the Yukon by Ventek Energy Systems Inc. and are referenced in the rest of this report because they are CSA approved, available in Canada, and have capacities within the range required at Yukon College. These boilers are underfeed combustion wood-fired boilers and can be set up to burn wood chips, wood pellets or crushed wood briquettes. The boiler brochure and specifications are shown in Appendix A.

Photo 10: Dual Pyrotec boiler installation

With respect to the boiler itself, there is approximately $40,000 in cost savings when burning pellets; a smaller auger is required, and the multi-cyclone is eliminated, which is discussed in more detail in the emissions control section below. Due to the higher consistency of the fuel, the boiler also burns more efficiently and has lower emissions than with chip fuel. With emissions control equipment, wood chip combustion emissions can be reduced to below pellet combustion emission levels.

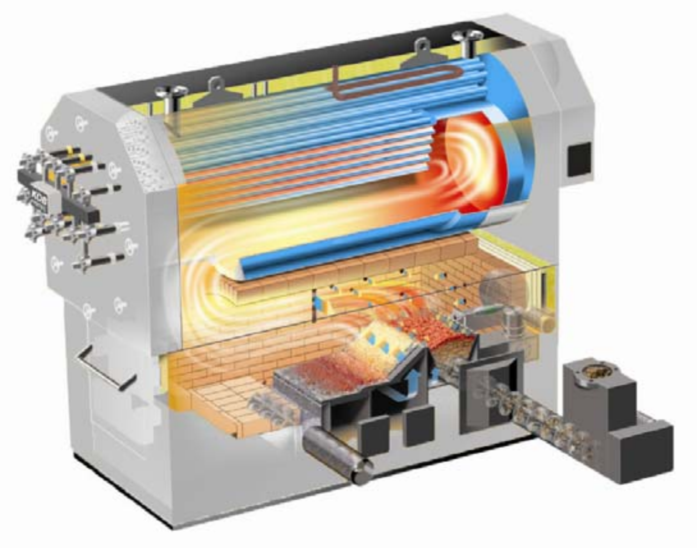

Photo 11: Pyrotec boiler cutaway

The KÖB Pyrotec has automatic CSA approved boiler controls, which are extremely important in reducing operator work, load, maintaining system efficiency and reducing emission levels. Automatic controls can accommodate some variability in wood chip fuel's moisture content, density and size with adjustments to fuel feed rates and oxygen flows. They also control staging required for a two-boiler system and can interface with the existing building management system.

Each boiler requires an ash collection system including an ash extraction auger and sealed metal container installed adjacent to the boiler. With the Pyrotec 950 boilers, an 800 litre ash bin would be installed adjacent to the boiler and at the Yukon College would need to be emptied in the landfill approximately twice a year.

A thermal storage system is required for optimum performance of these boilers. As discussed in paragraph 3.2.1, there are presently three tanks installed for this purpose which could be used for the new biomass boiler system.

A heat exchanger would likely be required to isolate the new biomass boiler system from the existing heating system. This isolation is important when the two systems have differing operating pressures. Presently, the boiler plant is operating at approximately 32 psi, however it was originally designed for higher pressure and the pressure relief valves are set at 100 psi. The biomass boilers are only rated for 30 psi. Either the entire heating plant must operate to a maximum of 30psi, or a heat exchanger is required for pressure isolation.

Each boiler would require two primary heating water circulation pumps (one of these would be for backup) located adjacent to the boilers in the heating plant building. These would be tied-into the existing heating system with new piping and insulation. The simplest tie-in locations would be at the existing connections of the gasifier B1 or boiler B2 should they be removed. Other tie-in locations should be evaluated if B1 and B2 are to remain in place.

6.3 BUILDING

Based on two Pyrotec 950 kW boilers requiring foundations of 11.2 m^2 each and another 40 m^2 to 60 m^2 of space for the ash collection bins, pumps, and associated equipment, the total footprint of the biomass boiler plant would be in the neighbourhood of 80 m^2. With the installation of an electrostatic precipitator emission control (discussed in subsection 6.5) another 30 m^2 would be required.

There are two options for housing the biomass boilers; provide space within the existing energy centre, or build a new building adjacent to the energy centre. If gasifier B1 and boiler B2 were removed, there would be adequate space in the energy centre to house the two new biomass boilers, as shown in Appendix D. Locating the boilers and associated equipment within the energy centre would be significantly less costly, however it would provide the bare minimum of space required for the new heating system resulting in an installation that would be a bit of a “tight squeeze”. On the other hand, tie-in of the boilers to the existing heating plant and distribution system would be simpler due to their proximity. The removal of the other two boilers would leave capped connections that would offer easy tie-in points as well as potential chimney penetration locations.

Should a new building be built for the biomass boiler plant, it would be located adjacent to the existing Energy Centre and would be constructed to northern standards (minimum wall insulation value of R28, minimum roof insulation value of R40). It would be heated with hydronic unit heaters and have the required combustion of air of approximately 945 litres per second for the boiler systems.

The two options for boiler plant location and a preliminary layout are shown in Appendix D.

6.4 STORAGE & FUEL CONVEYOR

The type of storage will be dependent on the type of fuel chosen for the biomass boilers. It is estimated that at peak 12 tonnes per day of wood chips or 9 tonnes per day of pellets would be consumed. The CANMET report evaluated a few options for storage for the gasifier B1 and these are equally valid options for the biomass boiler system.

It is recommended to use a silo for pellets and a storage bin for chips primarily because the silo augers are sensitive to material size and prone to jamming. Wood chips are not consistently sized, as are pellets. When jamming occurs and the entire weight of the wood fuel is on top of the screw auger, it can be difficult to repair. Photo 9 shows inconsistently sized wood chips in the existing bunker at Yukon College. It would be imperative to design the wood chip feed system with an adequate filter to eliminate larger chips that would result in maintenance problems.

Photo 12: Pellet storage silo

6.4.1 Storage Silo

A 112 m^3 storage silo would provide 9 days of pellet storage. Photo 12 shows an example installation of a larger silo. Specifications for a GSI silo are included in Appendix A. The existing storage bunker could add another 60 m^3 of storage capacity raising the total to 2 weeks for pellets. A reliable conveyor would have to be installed from the bunker to the boilers' feed augers for this extra storage to be useful.

A 15 metre long 30cm wide portable belt conveyor would be required to fill the silo from the delivery trucks. From the silo, the pellets would be conveyed either to the underground bunker or directly to the boilers via an auger and flexible hose system, either mechanically or pneumatically.

6.4.2 Storage bin

A double (80 ton) walking floor storage bin would provide 280 m^3 or 5 days of chip storage. Photo 13 shows a similar bin half the size that would be required. As noted above, the existing storage bunker could add another 60 m^3 of storage capacity but the existing auger would need modifications to accommodate wood chips. This type of bin is advantageous because the delivery truck can drive right into it and dump its load in the bin. The truck would require a walking floor for unloading the chips. Otherwise they would be dumped outside and transferred via tractor and loader into the storage bin.

Photo 13: Single (40 ton) drive in covered storage bin

It is imperative for this type of storage that the chips are dry and not susceptible to freezing and clumping, otherwise transfer of chips with the augers could be problematic. The supplier would have to guarantee that the chips are always covered prior to delivery.

If a consistent chip delivery cannot be guaranteed, then a large capacity underground storage bunker that is less influenced by freezing temperatures or a heated storage would be necessary.

Table 3 outlines the features of the two storage options.

	Pellet Silo	**Walking Floor Chip (or Pellet) Bin**
Capacity	112 m^3 (9 days)	280 m^3 (4 - 5 days)
Footprint	18' diameter (24 m^2)	62' x 24' (138 m^2)
Height	27' (8.2 m)	21' (6.4 m)
Fill	Portable belt conveyor	No extra equipment (truck dumps load in bin if equipped with walking floor)
Unload	Auger to flex flow system	Walking floor to auger
Fire Safety	Less safe (cannot remove biofuel)	More safe (can extract biofuel from back door)
Biofuel	Sensitive to size	Not sensitive to size
Maintenance	Difficult to ease load from auger if jamming occurs	Floor can be reversed to remove fuel load from auger Easy access to hydraulics under floor
Cost	~$105,000	~$650,000

Table 3: Wood fuel storage options

6.5 EMISSIONS CONTROL & MONITORING

6.5.1 Emissions Control

The potential installation of a biomass boiler plant raises immediate questions about emissions. Products of combustion that are of concern are sulphur oxides (SOx), Nitrogen Oxides (NOx), Carbon Monoxide (CO), Volatile Organic Compounds (VOC's) and Particulate Matter (PM10 is particulate matter 10 microns or less in diameter, PM2.5 is fine particulate matter 2.5 microns or less in diameter).

The existing oil-burning boilers produce SOx, NOx, CO, and VOC's in comparable or greater quantities than wood biomass boilers do. However, almost all wood burning systems have significantly higher particulate matter (PM) emissions than do equivalent oil (and gas) systems. Particulate Matter is known for its adverse effects on the human respiratory system, thus it is necessary to focus emission control on effectively reducing ground-level concentrations of PM to acceptable levels.[4] What is an acceptable level? As noted in section 7, there is no legislated acceptable level in the Yukon. There are European standards, there are Canadian ambient standards, there are local municipal limit standards in other Canadian cities and there are industry leaders that set their own standards. Therefore, an acceptable level is dependent on the political will and economic climate. In this case, an achievable level of PM2.5 emissions that meets or

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[4] Reference: Biomass Energy Resource Center
http://www.biomasscenter.org/resources/fact-sheets/fse-biomass-emissions.html

exceeds most standards here and worldwide is between 10 and 50 mg/Nm^3 (the European limit value is presently 50 mg/Nm^3 but is in the process of being reduced, the Greater Vancouver Regional District limit value is 15 mg/Nm^3).

The following emission controls are available:

"PM controls: There are several technically feasible combustion control options available for boilers that will reduce emissions below 0.10 lb/mmBtu per hour. In order to reach these emission levels, boiler operations must be optimized and advanced emission control devices, such as fabric filters and electrostatic precipitators, installed.

CO controls: There are no post combustion technologies available for these units; therefore boiler optimization is the best approach to minimizing CO emissions.

NOx: While there are several technically feasible options available that would reduce NOx emissions from wood chip boilers, the costs associated with these units are likely to deem them economically infeasible."[5]

The combination of emission control devices and advanced boiler designs on biomass boilers is common in Europe, but is limited in North America. As the market continues to grow, these products will likely be more available in Canada and the US. The European-made Pyrotec boilers claim to have PM2.5 emissions in the range of 80 – 100 mg/Nm^3 without added emissions control equipment when burning pellets. With emission control equipment, the emissions from these boilers could be in the 20 mg/Nm^3 range and below for pellets or chips, depending on boiler loading. A multicyclone is required with a chip-burning boiler to remove some of the PM10 emissions, however it is ineffective for PM2.5 removal.

Table 4 summarizes the emission control options and their applicability.

Both the baghouse and the electrostatic precipitator are effective particulate matter removers. The precipitator is more flexible as it is installed in sections based on the required particulate removal level. It also has lower maintenance requirements, has less fire hazard, and does not add resistance to the boiler. The baghouse is a simpler filter system that costs less per unit, however one unit is required for each boiler whereas the precipitator can be used for both boilers. Brochures for each of these can be found in Appendix A.

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[5] Reference: Northeast States for Coordinated Air Use Management (NESCAUM) *Controlling Emissions from Wood Boilers* October 10, 2008 http://www.nescaum.org/topics/commercial-wood-boilers

Control	Removal Effectiveness	Installation Cost ($1000)*	Maintenance Cost ($1000)*	Comments
Cyclone		15-20	minimal	Inexpensive
PM_{10}	~50 %			Ineffective at removing fine PM
$PM_{2.5}$	0 to 10%			Ineffective at removing gas phase PM (condensable PM)
Multicyclone		20-30	minimal	Inexpensive
PM_{10}	~75 %			Ineffective at removing fine PM
$PM_{2.5}$	0 to 10%			Ineffective at removing gas phase PM (condensable PM)
Core Separator		160-260	Unknown	Questions about availability
PM_{10}	> 98 %			Questions regarding effectiveness
$PM_{2.5}$	> 98 %			
Baghouse / fabric filter		200	10	Higher cost
PM_{10}	> 98 %			Effective at removing fine PM
$PM_{2.5}$	> 98 %			Able to capture condensable PM
Electrostatic Precipitator		200-400	1-2	Higher cost
PM_{10}	> 90 %			Effective at removing fine PM
$PM_{2.5}$	> 90 %			Ineffective at removing gas phase PM (condensable PM)

*Cost based on >2 x NESCAUM reference costs (2008 $US dollars, smaller systems, does not include transportation or taxes).

Table 4: Summary of Potentially Applicable PM Control Devices[6]

6.5.2 Emissions Monitoring

Boiler emission limitations should be established during the design process. Once the system is installed, an initial test for purposes of determining compliance with the boiler emission limitations can be conducted. This test would include continuous sampling of gases (CO_2, O_2, CO) over a set period of time, testing of condensable gases which are those that are not detected until cooled (in the atmosphere) and particulate matter testing with a cascade impactor. This initial test should be conducted within the first two months of operation for warranty purposes, and again after the boilers have been running for an established break-in period of time.

Appendix C has more detailed information on testing methodology and sample pricing.

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[6] Reference: Northeast States for Coordinated Air Use Management (NESCAUM) *Controlling Emissions from Wood Boilers* October 10, 2008 http://www.nescaum.org/topics/commercial-wood-boilers

6.6 EXISTING EQUIPMENT

This heating plant would rely on the existing infrastructure including: existing boilers B3 and B4 for peak heating conditions, thermal storage (accumulator) tanks, and existing heating water distribution system (piping & fittings, pumps, expansion tanks, domestic hot water heating equipment, chemical pot feeder, heating equipment in and beyond the Energy Centre). It would also be beneficial to make use of the underground storage bunker as noted in subsection 6.4 above.

6.7 OPERATOR REQUIREMENTS

The Boilers and Pressure Vessels Act Regulations require supervision by a person holding 4th class power engineer's certification for heating systems over 750 kW in size, and by a person holding a 3rd class power engineer's certification for heating systems over 3000 kW in size. The Chief Boiler Inspector (presently Mr. Daniel Price 667-5765) has the authority to designate what supervision is required. Mr. Price has indicated that the regulations are in the process of being changed so that a 5th class power engineer can operate a heating plant up to 3000 kW in size.

The following table outlines the supervision requirements for the heating plant with two new 950 kW biomass boilers.

Operator Requirements (with 2 new 950 kW biomass boilers)					
	Plant Options	**Total Plant kW**	**4th or 5th Class**[7]	**3rd Class**	**Hrs./Days per week**
1	Keep existing plant (with B1 tied-in)	10,329 kW	Operators	Supervisor	24/7
2	Remove B1 only	7,398 kW	Operators	Supervisor	When B2 operating
3	Remove B1 and B2	3,441 kW	Operators	Not required	8/5

Table 5: Summary of Operator Requirements

The operator requirements listed in Table 5 are based on the assumption that the plant remains a "heating plant" and not a "power plant", the basic difference being operating pressure, where a heating plant must have a working pressure less than 1100 kPa. The heating plant is presently operating at 220 kPa but has a maximum working pressure (pressure relief setting) of 690 kPa. Boiler B2 is a "power boiler" built for high pressure, and despite its operation solely as a heating boiler, its presence requires the supervision of a 3rd class power engineer while it is in operation. The removal of this boiler B2 will undoubtedly lower the supervision requirements of the plant.

In discussions with Mr. Price, the installation of two low pressure biomass boilers and the removal of boiler B2, which brings the total plant capacity to 3,441 kW (option 3 above), will

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[7] According to Mr. Price, Chief Boiler Inspector, a 5th class engineer is trained specifically for heating systems and may be more qualified for operating a heating plant than a 4th class engineer without experience in heating plants.

likely require a 5th class operator or an experienced 4th class operator 5 days per week. This is a reduction in operator requirements from the present installation.

One qualified person can maintain the two proposed biomass boilers, however the biannual cleaning is best done with two people. The estimated maintenance hours for a dual Pyrotec 950 would be 164 man-hours per year. This includes cleaning and lubrication of the system, biannual shut-down & cleaning, and biannual ash removal and disposal.

Since the Yukon College already has qualified personnel maintaining the existing boiler plant, the new biomass boiler plant can take advantage of this in-house expertise. The increased maintenance with an additional boiler plant may partially be compensated for by reduced maintenance for the existing system.

Initial training for the operators is required and would be in the order of two full days. The boiler supplier provides this training.

6.8 UTILITY REQUIREMENTS

The increased electrical loads that this new heating plant will incur on the college have to be evaluated for utility service size, and back-up power requirements (i.e.: does it need to operate during a utility power interruption?).

The ideal source of electric power will be the Energy Centre itself, however, it could be sourced directly from the electric utility if necessary. The availability of power from the energy centre, and/or the utility would have to be evaluated. Should the increase in demand exceed the existing infrastructure, this could involve expensive alterations.

Three phase, 600 volt electric power is supplied to the Energy Centre and thus is the power of choice. As the boilers run on 208 volt three phase power, and depending on the HP rating of any other motor loads, they can be sourced by 120 volt, 208 volt single phase, or 208 volt three phase power. This would require an appropriately sized transformer installed either outside or inside the new building.

Other considerations would be the requirement of a fire alarm system, security, and communications.

6.9 GEO-TECHNICAL CONSIDERATIONS

Due to the large size and weight of both storage system options (silo or bin), either a well-compacted gravel pad or a concrete foundation will be required. This will need to be engineered to determine the appropriate size and depth of footings.

7 REGULATORY OBLIGATIONS AND STANDARDS FOR EMISSIONS

7.1 AIR EMISSIONS STANDARDS WORLDWIDE

The BC Lung Association summarizes the regulatory standards for particulate emissions in this way:

"In response to scientific evidence of statistically significant associations between exposure to particulate matter and adverse health impacts, regulatory activity has focussed on developing new criteria to reduce or limit exposure to PM2.5. The Province of Newfoundland and Labrador took early action by adopting a PM2.5 standard in 1996. The U.S. Environmental Protection Agency promulgated revisions to its National Ambient Air Quality Standards (NAAQS) to include a new standard for PM2.5 in 1997. Canada followed suit with the start of the development of the Canada-Wide Standards (CWS) in 1997, culminating in the adoption of the current CWS for PM2.5 in 2000. Australia and New Zealand have also adopted monitoring and reporting standards, while the European Union is considering recommendations from the European Commission on new Limit Values, or a concentration cap and prescribed reductions in PM2.5 emissions."[8]

There is a chart in Appendix C from the same source that identifies the main regulatory status for particulate matter worldwide. The NAAQS, CWS, EU and UK Air Quality Standards are also found in Appendix C for reference. These all attempt to limit ambient levels of pollutants but do not specify limit values to be respected for individual applications.

7.2 AIR EMISSIONS REGULATIONS IN YUKON

The Yukon's *Air Emissions Regulations* under the *Environment Act* have three pertinent clauses. In terms of emissions content, the only requirement is that the sulphur levels of the fuel itself not exceed 1.1%, which should not be a problem with a biomass boiler that burns wood as its fuel.

The second clause of importance pertains to the opacity of the emissions, limiting them to 40% from one source. This also is not burdensome with modern biomass boiler design.

These regulations will, however, require that a permit be obtained for the new heating plant. Schedule 1 of the regulations lists activities that require a permit, and the activity that relates to the biomass heating plant is quoted below:

> 5. Operation of equipment capable of generating, burning or using, according to the manufacturer's specifications, heat energy equivalent to or greater than 5,000,000 British Thermal Units per hour.

7.3 YESAA

This proposed project will require an assessment under the *Yukon Environmental and Socio-economic Assessment Act* (YESAA) if three conditions are met.

1. The project will be located in the Yukon.

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[8] Reference: BC Lung Association *Development of Options for a New Provincial PM2.5 Air Quality Objective: Summary Report* December 2005 http://www.bc.lung.ca/pdf/phase1.pdf

2. The federal YESAA regulations list the project activity as subject to assessment.
3. The proponent has applied for financial assistance for the project to a federal agency or federal independent regulatory agency.

Conditions 1 and 2 above are met for this project since the YESAA regulations list “Operation of equipment capable of generating, burning or using heat energy” “unless it is not capable of generating, burning or using, according to the manufacturer’s specifications, heat energy of 5,000,000 Btu/h or more” as subject to an assessment.

If funding from a federal agency (condition 3) is to be considered, an assessment will be required.

7.4 CANADA-WIDE STANDARDS

In June 2000, the Canadian Council of Ministers of the Environment endorsed the *Canada-Wide Standards for Particulate Matter and Ozone*, which comprise ambient standards to be achieved by 2010. These standards were developed as a first step toward the goal of minimizing the risk posed by these two pollutants to human health and the environment[9]. This standard limits over time the PM2.5 ambient level to 30 µg/m3 as a 24-hour average.

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[9] Reference: Environment Canada http://www.ec.gc.ca/cleanair-airpur/caol/pollution_issues/cws/s1_e.cfm

8 OPINION OF PROBABLE COST

The project costs are completely dependent upon the type of fuel, quality and size of boiler, type of storage system, location of boiler plant and level of emissions control. The options presented in the report above are summarized here with a class 4 (±30%) opinion of probable cost associated with them.

Option 1 – Pellet biomass plant within energy centre with emissions control = **$ 3,700,000**

This option includes the following:

- Two 950 kW CSA approved pellet boiler + plant equipment - $ 2,676,000
- Demolition of gasifier B1 and boiler B2 - $ 260,000
- Electrostatic Precipitator Emissions Control - $ 627,000
- Storage Silo - $ 105,000

Option 2 – Chip biomass plant within energy centre with emissions control = **$ 4,300,000**

This option includes the following:

- Two 950 kW CSA approved chip boiler + plant equipment - $ 2,728,000
- Demolition of gasifier B1 and boiler B2 - $ 260,000
- Electrostatic Precipitator Emissions Control - $ 627,000
- Storage Bin - $ 650,000

Option 3 – Pellet biomass plant in new building with emissions control = **$ 3,900,000**

This option includes the following:

- Two 950 kW CSA approved pellet boiler + plant equipment - $ 2,676,000
- New building - $ 498,000
- Electrostatic Precipitator Emissions Control - $ 627,000
- Storage Silo - $ 105,000

Option 4 – Pellet biomass plant within energy without emissions control = **$ 3,000,000**

This option includes the following:

- Two 950 kW CSA approved pellet boiler + plant equipment - $ 2,676,000
- Demolition of gasifier B1 and boiler B2 - $ 260,000
- Storage Silo - $ 105,000

Other combinations may be considered and evaluated based on the above information.

The following assumptions have been made to evaluate the costs noted above:

- The energy centre has sufficient electrical capacity to support the extra demand

- Utility power will be sufficient (not on backup-generator)
- The existing heating plant and distribution system downstream of the boilers are adequate for the tie-in of the new biomass plant.
- The market is competitive and a public or invitational tender will be conducted with at least three valid bids
- The biomass plant will be constructed in the upcoming construction season (2010)
- Inflation, taxes and permitting fees are not accounted for

Appendix A: Equipment Information

VIESSMANN

climate of innovation

Heating with Wood

Why Wood Heating?

Rising cost of fossil fuels and growing concern for the environment have led to an increasing demand for renewable energy. Modern wood heating is an eco-friendly and economical alternative (or addition) to conventional fossil fuel heating systems.

Did you know?
A number of federal, state and utility incentive programs are available throughout North America.
Visit www.dsire.org for a list of U.S. state incentive programs.
In Canada, check the Natural Resources Canada website www.nrcan.gc.ca. Or contact your local Viessmann Sales Representative.

Sustainable
When harvested in conjunction with sustainable forestry, wood is a renewable and environmentally-responsible form of energy and an important part of sustainable resource management.

CO_2-neutral
Burning wood releases as much CO_2 as trees absorb in their lifetime. Heating with wood is therefore CO_2-neutral and does not contribute to climate change.

Economical
As a local energy source, wood is affordable and independent of wide price fluctuations. In times of volatile energy prices, wood remains stable and highly competitive.

High-tech and reliable
Modern biomass systems are fully-automatic and equipped with high-tech control and safety devices for reliable, efficient and safe operation.

Local and independent
Wood is a local staple and independent of wide price fluctuations. Wood is harvested with minimal energy input and contributes to the regional economy.

What You Need to Know

What type of wood can I use?

Viessmann-KÖB wood heating systems can use a variety of untreated, high-quality wood fuels that vary in heating value, required storage capacity and cost (see right column). What fuel type you choose will largely depend on your storage capacity, system requirements and the availability of the fuel in your area. As the quality of the fuel impacts the efficiency and life expectancy of your system, it is best to choose a good-quality, untreated wood fuel with a low water content.

How economical is it?

In a biomass system, the operating cost (fuel and maintenance) is an estimated 60% of the total lifecycle cost. Choosing a high-efficiency wood-fired boiler and high-quality, cost-efficient wood fuel thus is key in optimizing the economy of your system. Compared to traditional fossil fuels, the average cost per heat unit of wood fuel is significantly lower in most areas in North America. So while the investment cost of a biomass system may in many cases be higher than a conventional heating system, the fuel cost savings per unit of heat can offset the investment in a relatively short timeframe - making your biomass system as economical or better than a fossil fuel heating system. Plus, with a fuel source that is local and independent, your fuel cost is less volatile than with traditional fuels.

Is it safe?

Absolutely. Today's wood heating systems are as safe and reliable as leading gas/oil heating systems. Equipped with advanced safety and fire protection devices, and a digital control, the entire system is closely monitored and controlled - from the fuel feed right to the heat transfer and venting.

Viessmann-KÖB wood-fired boilers are built to ASME, Section IV requirements, are CRN registered, and have been tested to CSA/UL Safety Standards (including all safety controls).

Is it clean-burning?

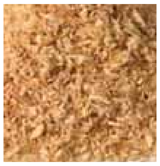
Yes! Modern wood heating systems, when professionally operated and maintained, reach similar emission levels to leading fossil fuel heating systems. Better yet, wood heating is CO_2-neutral. Viessmann-KÖB wood-fired boilers meet the stringent regulations of the European Clean Air Act.

What applications can it be used for?

Our wood heating systems are ideally suited for commercial and industrial applications, such as schools, hospitals, community heating systems, wood processing plants and more. They are designed to carry either the entire heating load of your system or the baseload, when combined with an oil-/gas-fired boiler for peak times.

Our comprehensive product portfolio also allows you to expand your biomass installation into a fully integrated system, complete with Viessmann solar, oil/gas boiler and custom control technology (see page 13).

Pellets
Most compact wood fuel with least storage required. High heating value.

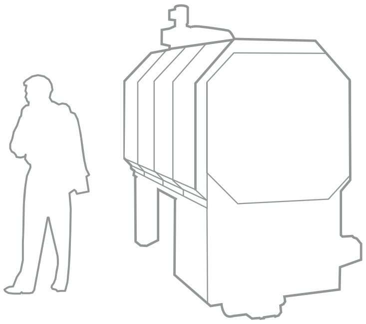


Sawdust
Untreated sawdust. Ideal for small storage. Sawmills, carpentry, wood processing facilities.

Woodchips
Shredded, untreated, with or without bark. Large storage required. Max. size: G50. Max. water content: 50%.

Mixed Woods
Unprocessed mix of woodchips, sawdust and bark. Max size: G50.

One of Germany's largest facilities powered by KÖB biomass heating technology.
Recreational Pool and Spa. Kempten, Germany.



PYROT

Industry-leading rotary combustion wood-fired boiler, 512 to 1843 MBH

For wood fuels with max. water content of 35%

Industry-leading design

With its patented rotary combustion chamber design, the Pyrot boiler features the industry's most advanced combustion technology.

A feed auger continuously moves the wood fuel onto a moving grate, where gasification of the fuel (under precisely controlled primary air) takes place. The combustible gases (syngas) then rise into the rotary combustion chamber, where, through spin impulses of the rotation blower, the gases blend with precisely controlled secondary air, resulting in a complete combustion.

Clean-burning and efficient

Equivalent in quality to modern gas combustion, the advanced combustion process of the Pyrot also keeps emission levels of CO (<10 ppm), NOx (<75 ppm) and dust particles (<0.06 lb/MMBtu) to a minimum.†

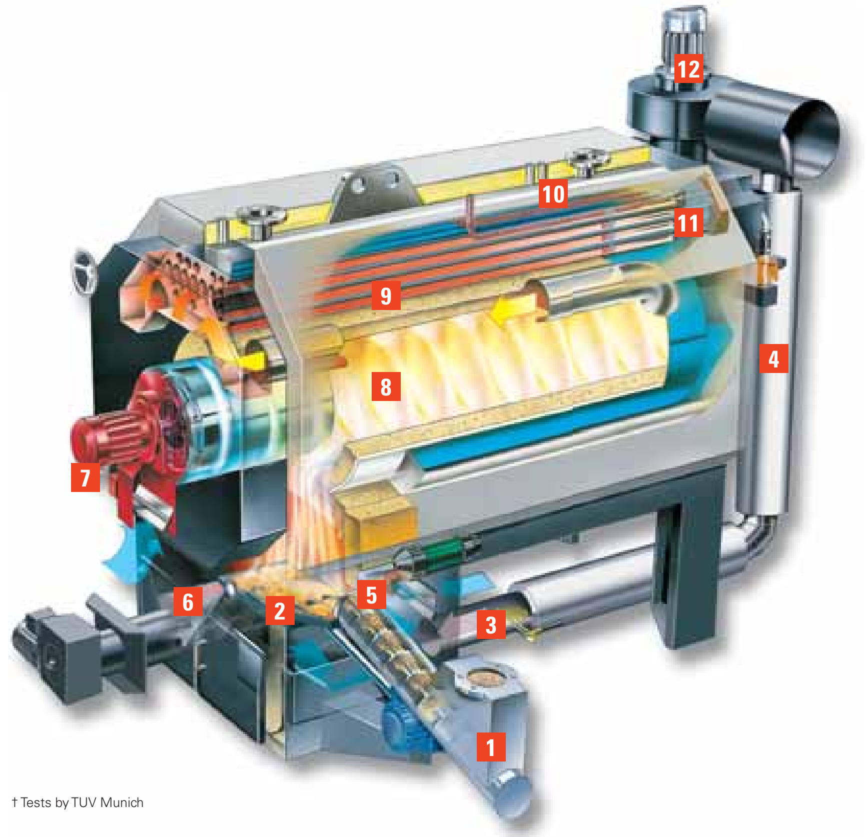
Plus, unlike oil or gas, wood is a CO_2-neutral, renewable form of energy. Used with our digital, modulating-output control, the Pyrot boiler achieves an efficiency of 85%.

Containerized package

The Pyrot is available as a fully containerized package for applications where housing for the boiler is not available or onsite construction costs must be kept to a minimum.

This pre-packaged solution includes the boiler pre-installed in a specialized shipping container (see page 5) and all peripheral equipment.

Customized containerized packages are available to suit your individual needs.



1 Feed auger (with light barrier)
2 Moving grate
3 Primary air control valve
4 Flue gas recirculation system
5 Ignition fan
6 Deashing system
7 Secondary air control valve with rotation blower
8 Rotary combustion chamber
9 Triple-pass heat exchanger
10 Safety heat exchanger
11 Pneumatic pipe cleaning system
12 Induced draft fan

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† Tests by TUV Munich

Pyrot with ash removal auger and external ash container

Containerized boiler package
(pellet silo field supplied)

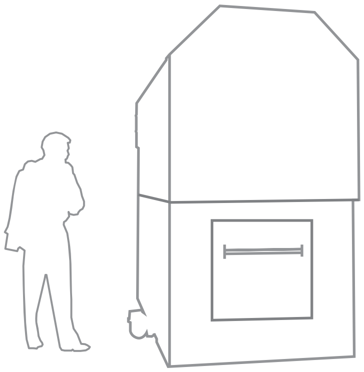
Specifications

- Fully-automatic rotary combustion wood-fired boiler
- 5 models from 512 to 1843 MBH
- For dry wood fuels with max. water content of 35%
- Efficiency: 85%
- Available for 30 or 60 psig max. operating pressure

For technical data, see page 12.

Benefits at a Glance

- High efficiency with advanced combustion technology, triple-pass heat exchanger and modulating output control (turndown ratio 4:1).
- Maximum heat transfer with triple-pass heat exchanger design.
- High efficiency and ultra-low emissions with precisely controlled primary and secondary air.
- Automatic ignition device limits idling and saves fuel.
- Low maintenance with fully-automatic deashing, optional pneumatic cleaning system and flue gas deduster.
- Advanced safety equipment ensures safe and reliable operation.
- Custom design of your system by our team of experts.
- Available as convenient containerized package.



PYROTEC

State-of-the-art underfeed combustion wood-fired boiler, 1330 to 4268 MBH

For wood fuels with max. water content of 50%

Grate firing at its best

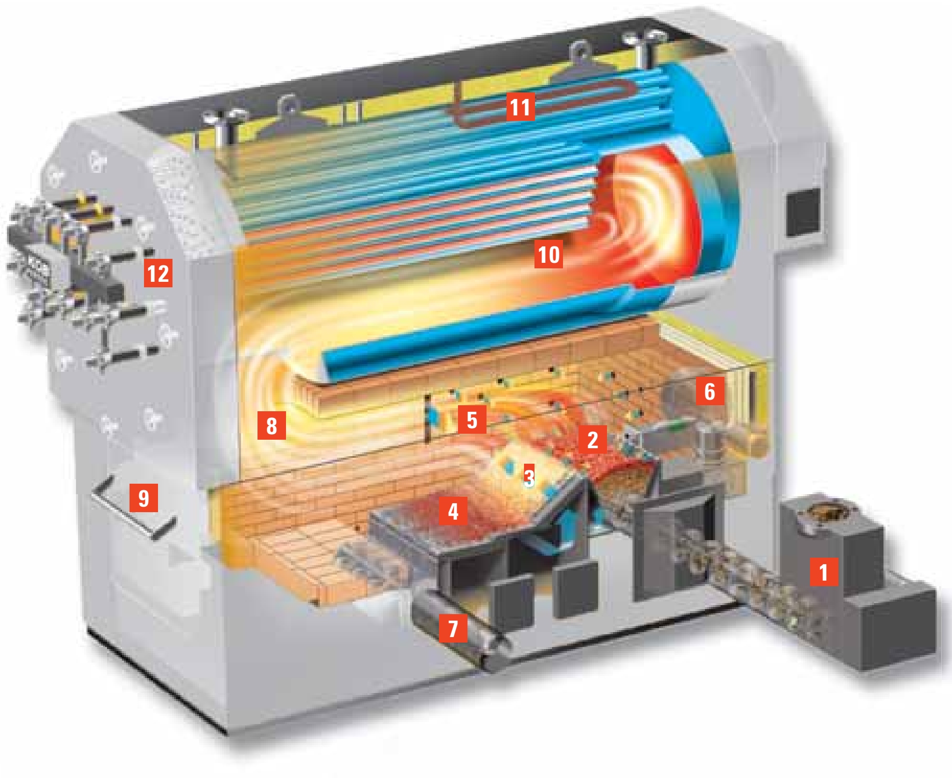
The Pyrotec boiler uses a burner trough with an attached external grate and a moving annealing grate to achieve optimal combustion results. A feed auger moves the wood fuel into the burner trough where the fuel is pre-dried and gasified under precisely controlled primary air (underfeed combustion). On the external and the moving annealing grate the fuel completely gasifies (syngas). Precisely controlled secondary air is injected to fully combust the syngas and thermal energy is released into the boiler's triple-pass heat exchanger.

Quality design and construction

The Pyrotec boiler is quality-constructed to handle the toughest of loads. The combustion chamber is lined with compressed firebricks with a high alumina content for added durability. All grate elements are made of durable cast chrome steel to withstand even the highest temperatures. The Pyrotec boiler features a classic triple-pass heat exchanger design for maximum heat transfer and efficiency.

Clean-burning and efficient

Equivalent in quality to modern gas combustion, the advanced combustion process of the Pyrotec keeps emissions of CO and NOx to levels comparable to those of modern fossil fuel heating systems. Plus, unlike oil and gas, wood is a CO_2-neutral, renewable form of energy. Used with our digital, modulating-output control, the Pyrotec boiler achieves an efficiency of 85%.



1	Feed auger (with light barrier)
2	Burner trough with internal grate
3	External grate
4	Moving annealing grate
5	Secondary air flow
6	Ignition fan
7	Deashing system
8	High-temperature burnout zone
9	Combustion chamber door
10	Triple-pass heat exchanger
11	Safety heat exchanger
12	Pneumatic pipe cleaning system

Pyrotec boiler with feed auger and automatic fire-extinguishing safety system

Firebrick-lined combustion chamber with external grate and moving annealing grate.

Large, air-cooled combustion chamber door with solid double hinge. Creates a wide opening ideal for maintenance.

Specifications

- Fully-automatic underfeed combustion wood-fired boiler
- 5 models from 1330 to 4268 MBH
- For wood fuels with max. water content of 50%
- Efficiency: 85%
- Available for 30 or 60 psig max. operating pressure

For technical data, see page 12.

Benefits at a Glance

- High efficiency with advanced combustion technology, triple-pass heat exchanger and modulating output control (turndown ratio 4:1).
- Maximum heat transfer with triple-pass heat exchanger.
- High efficiency and ultra-low emissions with precisely controlled primary and secondary air.
- Low maintenance with fully-automatic deashing, optional pneumatic cleaning system and flue gas deduster.
- Advanced safety equipment ensures safe and reliable operation.
- Maximum system performance with heavy-duty construction and all system components from one source.
- Automatic ignition device limits idling and saves fuel *(optional - only for fuels with >40% moisture content).*
- Custom design of your system by our team of experts.

Fully Automatic and Low Maintenance

A complete range of system components from one source ensures reliable and smooth operation of the entire system.

Flue gas deduster to meet low dust emission requirements.

Automatic deashing system *(optional)*
Clean combustion leaves behind wood minerals in the form of ashes. A moving grate extracts the ashes from the combustion chamber and transfers them into the ash bin. Once cooled, the ash removal auger extracts the ashes into a large external ash container.

Pneumatic cleaning system *(optional)*
A clean heat exchanger is key for the longevity and efficiency of a boiler. The pneumatic pipe cleaning system periodically removes ashes from the heat exchanger with micro blasts of compressed air, extending the boiler's maintenance-free operation period significantly.

Flue gas recirculation system
(standard for Pyrot, optional for Pyrotec)
Flue gas contains little oxygen (6-8%). When mixed with primary air, it ensures complete gasification of the fuel under air deficiency. This produces a low grate temperature that results in increased boiler efficiency, reduced particle emissions as well as greater grate longevity.

Flue gas deduster *(optional)*
Minimizes dust emissions by filtering the flue gases through a multi-cyclone array. Comes fully insulated with an exhaust fan mounted on the side or top, and a 64 USG ash container. A 212 USG ash container is optional.

(Only required for fuels with high fine particle content, e.g. waste wood from wood processing plants or woodchips with fine particle content of > 4%.)

Automatic firetube cleaning brush *(service tool)*
Automated, pneumatic, vibrating cleaning brush cuts the cleaning time of boilers by 50%. When inserted from the front and activated, the brush "runs" through the individual tube and back, gently removing ash and dust deposits. Clean fire tubes ensure optimal heat transfer and increased efficiency.

Ash removal auger and external ash container

Pneumatic cleaning system

Flue gas recirculation system

Complete Energy Management

High-tech modulating-output control systems for maximum and safe performance of the heating system.

Modern biomass control systems provide the same control convenience as most standard fossil fuel control technology.
Equipped with a modulating-output control and a thermal storage tank, the system supply temperature can be accurately modulated to outdoor weather conditions.

Ecotronic boiler control *(for Pyrot)*
Digital modulating-output control ensures optimal combustion by precisely controlling the ratio of combustion air, recirculated flue gas and fuel. The control monitors:

- Boiler supply/return temperatures
- Firebed level
- Light barriers of the feed system
- Flue gas temperature
- O_2 content of flue gas (Lambda sensor)

Pyrocontrol boiler control *(for Pyrotec)*
Fully-programmable modulating-output combustion and system control. The control regulates all variable-speed fans and monitors:

- Boiler supply/return temperatures
- Light barriers of the feed system
- Pressure sensor for reliable negative pressure
- Flue gas temperature
- Combustion chamber sensor (temperature high limit)
- O_2 content of flue gas (Lambda sensor)

Thermal storage tank
In a biomass system, a thermal storage tank is a key component in achieving maximum control accuracy (ability to adjust system output to actual demand). The storage tank facilitates temperature stratification, effectively reducing cycling of the firing system and accurately matching the system supply temperature to the heat demand.
Five sensor inputs are available on all controls for optimal burner modulation according to tank temperature.

Vitocontrol multi-boiler control
Custom control solution for the staging and rotation of two Pyrot or Pyrotec boilers and the energy management of other integrated energy sources (solar, oil/gas, electric). Controls joint storage and feed system and interfaces with Building Management Systems (BMS).

Remote monitoring system *(optional)*
Off-site monitoring and maintenance of the heating system via web-interface. Allows for the observation and adjustment of various system parameters. Optional LonWorks® and BACnet® interface for local supervision (other interfaces available upon request). Ideal for system monitoring in a public facility or at community/district heating plants.

CSA approved
All biomass control systems are built in-house, and are CSA approved in North America in conjunction with our wood-fired boilers. Plus, benefit from...

- fast installation with all functions in one control
- ease of service and maintenance
- wiring diagrams for each system

Ecotronic boiler control for Pyrot

Pyrotec boiler control

Storage and Feed Systems

Each fuel storage and feed system is unique and designed for a specific application. Our advanced, fully-automatic feed solutions come ready for installation.

All Viessmann-KÖB wood-fired heating systems come equipped with...

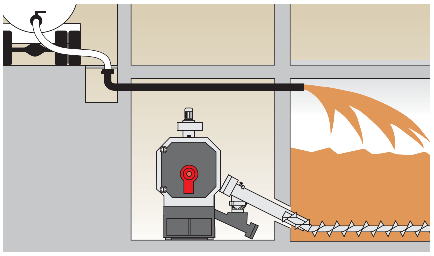
- large-diameter heavy-duty augers
- spur wheel back-geared motors for high torque
- optimized and large-dimension load passages
- certified equipment for effective fire protection

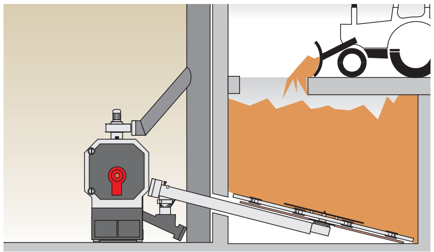
Basement storage with auger extraction
Basement rooms or rooms previously used for oil storage can be transformed into a pellet storage area without extensive remodeling. Pellets can be blown in over large distances and special feeders transport the pellets reliably and with little energy use.

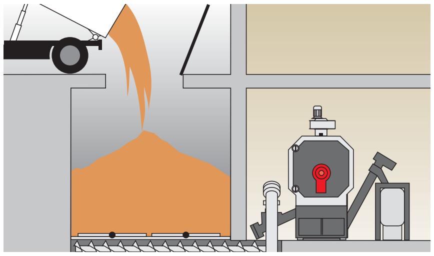
Bunker with rotary sweep extraction
A low-cost option for smaller square or slightly rectangular bunkers. A rotary sweep system moves the fuel onto an extraction auger.

Bunker with walking floor extraction
Ideal for large, rectangular storage bunkers. Sliding hydraulic pushrods move the fuel onto a conveyor auger. Allows for fast filling of large amounts of fuel.

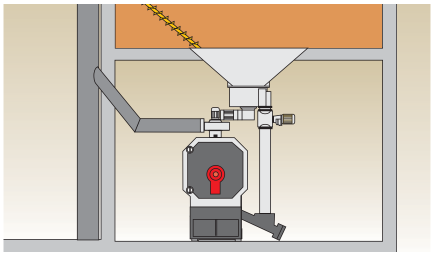
Silo funnel extraction
A pendulum system in the funnel extracts fuel from the silo. Fail-safe due to automatic reverse gearing. A fire-proof certified rotary valve separates the silo from the heating system. Recommended system for wood processing facilities.


Basement storage with pellet auger


Bunker with rotary sweep extraction


Bunker with walking floor

Walking floor installation


Silo funnel extraction

Safe and Reliable Operation

Viessmann-KÖB wood-fired boilers are built to meet the most stringent safety requirements. High-tech, state-of-the-art safety equipment ensures a safe and reliable operation of your system at all times.

Backflash safeguard
A water-filled metering container attached to the feed auger and controlled by an optical sensor. Prevents sparks from entering the fuel storage area. The backflash safeguard is a CSA safety requirement.

Burnback preventer
A sensor located in the fuel feed pipe detects any danger of burnback and quickly counteracts by increasing the feed to the boiler.

Burnback safeguard
A spring-loaded horizontally-acting slide valve interrupts the fuel line in case of power failure or danger of burnback.
If the fuel storage room is under negative pressure a rotary valve is used instead of the slide valve for the same function. The rotary valve prevents unwanted air leaks from reaching the combustion process.

Automatic fire-extinguishing system
A fire extinguishing water tank (25 ltr/ 6.6 USG) with flow switch will empty and prevent burnback in case of malfunction. If there is a shortage of water, the system will switch off automatically.

Safety heat exchanger
A safety heat exchanger built into the boiler connects to city water and prevents the boiler from overheating in case of a power outage. A non-electric, thermally activated valve is triggered at a fixed boiler temperature and cools the boiler water via indirect heat transfer through the heat exchanger.

Additional safety devices
In addition to the safety equipment listed, Viessmann-KÖB wood-fired boilers come with the standard safety devices required by the Safety Standards.

- Fixed temperature high limit
- ASME pressure relief valve
- Low water cut-off (LWCO)
- Pressure and temperature gages

The Pyrot and Pyrotec boilers are built to ASME, Section IV requirements and 30 or 60 psig max. operating pressure. They have been tested and approved to applicable CSA/UL Safety Standards. Pressure vessels for Canada are registered in each province with a Canadian Registration Number (CRN).

Technical Specifications

Pyrot Rotary Combustion Boiler

For wood fuels with water content < 35%

Model		**150**	**220**	**300**	**400**	**540**
Output	MBH	512	751	1024	1365	1843
	kW	150	220	300	400	540
Efficiency		85%				
Max. Operating Pressure		30 or 60 psig				
Dimensions (inches)	Height	70	80	80	90	92
	Length	92	97	97	110	120
	Width	40	52	52	62	62

Pyrotec Underfeed Combustion Boiler

For wood fuels with water content < 50%

Model		**390**	**530**	**720**	**950**	**1250**
Output	MBH	1330	1809	2457	3242	4268
	kW	390	530	720	950	1250
Efficiency		85%				
Max. Operating Pressure		30 or 60 psig				
Dimensions (inches)	Height	94	100	112	120	130
	Length	129	150	153	150	170
	Width	49	50	55	64	64

The Perfect Match for Your System

With Viessmann System Technology you can easily expand your biomass system and reap the added benefits from a fully integrated renewable energy system.

Wood-fired boilers are ideal for integration with one or more energy sources, such as fossil fuel or solar. Our comprehensive product portfolio offers heating solutions for all energy types that are far more than just individual heating components. Whether it's an oil/gas heating boiler or a solar thermal system, all are designed to integrate perfectly into one reliable and economical system.

Performance solar systems

Our high-performance flat plate and vacuum tube solar systems are ideal to heat domestic hot water and to provide space heating backup for your biomass system.

By integrating solar, you can offset your domestic hot water heating cost by as much as 65% (depending on size of solar system) and further reduce your environmental footprint.

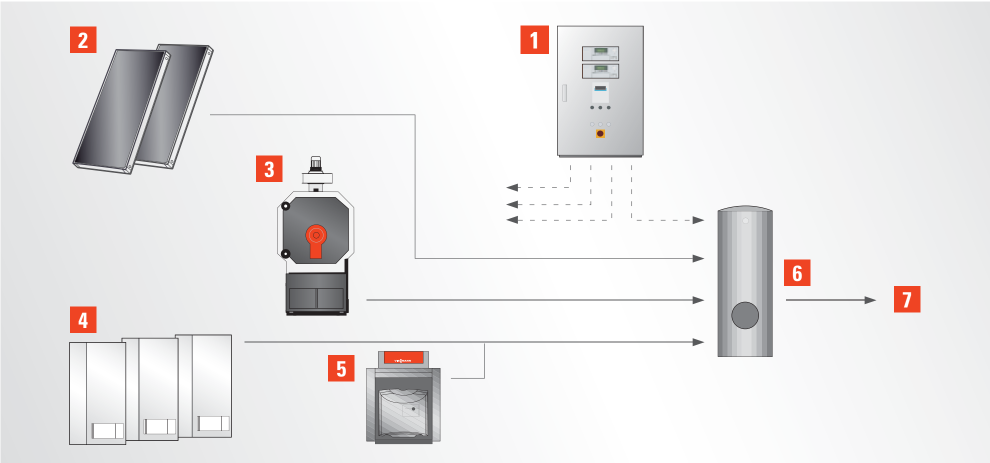
Powerful DHW tanks

Our Vitocell line of indirect-fired domestic hot water (DHW) storage tanks offers high-quality construction and fast recovery rates for an abundant, reliable hot water supply at all times. For applications with a high hot water load, combine our vertical or horizontal DHW tanks into tank batteries.

Integrating indirect domestic hot water heating in your biomass system can save as much as 50% in operating cost compared to conventional direct-fired hot water production.

Proven heating boilers

In an integrated renewable energy system, biomass heating is often coupled with conventional oil-/gas-fired boilers to handle peak loads or to provide backup to the biomass boiler. Depending on the type and temperature requirements of your system, Viessmann offers highly-efficient wall-mount and floor-standing condensing boilers or sectional cast iron boilers to integrate with your biomass system.



1 Viessmann custom control panel
2 Solar thermal system
3 Wood heating system
4 Condensing boiler(s)
5 Non-condensing boiler
6 Thermal storage tank
7 System distribution

Biomass Systems at Work

More than 1500 installations worldwide are powered by KÖB biomass technology.

KÖB biomass systems
For over 30 years KÖB has installed large-scale, wood-fired heating systems, and has earned recognition for innovative and environmentally-friendly product advancements. KÖB is part of the Viessmann Group of innovative, high-efficiency heating solutions and renewable energy systems.

KÖB

VIESSMANN Group

Portable Building Package
Harney District Hospital
Burns, Oregon

Design and commissioning services
Each Viessmann-KÖB installation begins with a system design from our in-house team of experts. By examining the unique requirements and conditions of your project, we propose a customized system solution – from a stand-alone wood-fired boiler to a fully integrated system, including fossil fuel heating and solar systems.

Comprehensive system solutions and services from one manufacturer!

Recreational Pool and Spa.
Kempten, Germany

Pyrotec Installation
Brunstad Congress Center, Norway

The Viessmann Group

Since 1917 Viessmann has been committed to providing heating solutions that are convenient, economical and environmentally responsible.

The Viessmann Group
For three generations Viessmann has provided efficient and environmentally-responsible heating solutions, tailored to the needs of our customers. Through ongoing research and product development, Viessmann has pioneered technologies that set standards and made the company a technological innovator and industry pacesetter.

KÖB-Viessmann
KÖB has been part of the Viessmann Group since 2007 and brings over 30 years of experience in wood heating. Specializing in high-quality large-scale biomass systems, KÖB is a valuable addition to the Viessmann Group, and contributes to our diversified product portfolio.

Viessmann International
With 13 manufacturing facilities in Europe, Canada and China, sales organizations in 36 countries, and 120 sales offices worldwide, Viessmann provides a strong global presence and customer proximity.
In North America, Viessmann has delivered state-of-the-art heating solutions for over 25 years. With three locations across North America, an outstanding support network and Academy training, Viessmann provides top-quality service and support that is second to none.

Our Values
Environmental and social responsibility, fair business practices, and striving for perfection and maximum efficiency in all company operations are core values for Viessmann. Together with our products and services, this allows us to offer our customers and partners the benefit and added value of a strong brand.

Innovative heating solutions and renewable energy systems for oil, gas, solar and biomass.

Residential and commercial systems up to 20 mW.

A multi-level program of heating products for every application and budget.

Designed to integrate seamlessly to ensure maximum system efficiency and performance.

Viessmann U.S.A Head Office
Warwick, RI

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Wärme aus Holz

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KÖB
Wärme aus Holz

Spec Sheet

PYRTEC Grate Firing System
Boiler Plant

7010-1

2006-02-01_E

Description:

The PYRTEC Boiler Plant combines in optimum fashion the advantages of underfeed firing with the advantages of grate firing. With its tried and trusted burner trough, drop-type external grate and travelling burn-out grate, outstanding controllability of output and maximum safety against burn-back are obtained along with automatic de-ashing of the furnace. This triple-phase firing system enables all-purpose use of the boiler plant from dry pellets (W5) (with flue gas recirculation system, see Accessories) to wet forest wood chips (W50).
This boiler plant has been inspected and approved in accordance with the latest quality criteria following EN 303-5 heating boiler for solid fuels, the CE certification as per European Machinery Directive 98/37/EC, with continuous quality control by TÜV and consists of:

FEED AUGER WITH ISOLATING LAYER:
A solid and heat-resistant feed auger with a powerful drive moves the material to be burned over the burner trough and into the grate zone, which drops down and travels.
Situated on the conveyor pipe are the holding devices both for the electrical safeguard against burn-back and for the thermal extinguishing valve. Above the auger there is the metering container with a light barrier for setting the level for the fuel isolating layer required according to TRD 414.
The drive is carried out by a maintenance-free spur wheel back-geared motor and chain drive in a dust-tight chain guard.
Inlet flange: 220 x 220 mm
Accessories: extinguishing valve with dirt trap, extinguishing water container with holding device

FIRING BLOCK:
The solid, horizontally positioned and large-volume firing block has been optimised in terms of incineration, consists of a high-quality fireclay brick lining and is multiply insulated for the lowest possible surface temperatures. The burner trough and incineration grates are made of highly refractory cast steel (material no: 1.4823; approx. 12 mm) and are individually replaceable.
In the lower part, the primary airflow is supplied to the incineration grates via a supply air fan (or flue gas recirculation system) in an output-controlled fashion and pre-heated.
In the upper part of the firing block, the secondary airflow is blown into the gas space of the firing system by an output-controlled fan via an encircling ring with high turbulence via individually adjustable nozzles. The firebox door is solidly constructed, air-cooled and very well insulated. Opening the firebox door with solid double-knuckle hinges is an ideal solution for maintenance purposes.

BOILER:
The hot-water boiler resting on the fire block has been thoroughly optimised to provide high heat transmission and a long service life. It is possible to mount the pneumatic cleaning system in the insulated door on the front of the boiler.
Located on top of the boiler is a cover that can be walked on, which makes installation and maintenance easier and protects the thermal insulation from getting damaged.
The boiler and fire block are well insulated and attractively encased.

Max. flow temperature:	100°C
Max. operating pressure:	3.0 bar

EXAHAUST FAN:
A fan especially for wood heating systems, very quiet, motor with a solid, heat-resistant design with heat dissipation hub and spring-supported. The fan housing on the intake port rotates infinitely variably, and the blow-out nozzle is round. It is usually mounted on the exhaust gas deduster (separately priced item).

ACCESSORIES include:

- Safety heat exchanger:	Built into boiler
- Counter-flange:	Forward and return flow, including bolts and seal
- Cleaning utensils:	Scraper for firing, cleaning brush (D 52 mm) with spring steel rod

ACCESSORIES for PYRTEC grate firing (Item KPT- …) at extra charge:

Designation	***Item***	***Text***	***Dimensions***	***Use***
Exhaust gas de-duster 240 l	*KPT-E…-2*	*7110*	*7110*	*Required (exception: pellets)*
Exhaust gas de-duster 800 l	*KPT-E…-8*	*7110*	*7110*	*Variation of 240-litre*
Preparation system for de-ashing	*KPT-AV*	*7120*	*-*	*Optional for KPT-A2-S*
De-ashing into bin, 240 l	*KPT- A2-S*	*7120*	*7010*	*Optional for KPT-AV*
De-ashing into skip 800 l	*KPT- A8-S*	*7120*	*7010*	*Variation of 240-litre*
Pneumatic cleaning system	*KPT-W…-S*	*7120*	*7010*	*Optional*
Electric ignition system	*KPT-ZG-S*	*7200*	*7010*	*not suited for > W40*
Set of displacement rods	*KPT-V…*	*7200*	*-*	*Base load boiler*
Flue gas recirculation system	*KPT-R…-S*	*7200*	*-*	*For fuels < W20*
Pyrocontrol control system	*PYR- …*	*7800*	*-*	*Required*

Spec Sheet

PYRTEC Grate Firing System Boiler Plant

7010-2

2006-02-01_E

Technical specs:

			PYRTEC Grate Firing System			
Trade name			***530***	***720***	***950***	***1250***
Item No:			***KPT-530***	***KPT-720***	***KPT-950***	***KPT-1250***
Performance data						
Rated heat output	Q_N	*[kW]*	*530*	*720*	*950*	*1250*
Continuous output 1)	Q_D	*[kW]*	*530*	*720*	*950*	*1250*
Minimum heat output 2)	Q_{min}	*[kW]*	*132*	*180*	*238*	*312*
Heat output, W45 chips	Q_{W45}	*[kW]*	*515*	*700*	*920*	*1210*
Efficiency in operation to be performed 3)		*[%]*	*> 90*			
Maximum water content 4)		*[%]*	*W 50*			
Size of the chips 5)			*G 30 / G 50 as per ÖNORM M7133*			
Exhaust gas figures						
Mass flow rate	Q_N; W5; O_2 8%;	*[g/s]*	*297*	*404*	*532*	*700*
Volume flow	Q_N; W5; O_2 8%; 150°C	*[m³/s]*	*0.36*	*0.48*	*0.63*	*0.83*
Mass flow rate	Q_{W45}; W45; O_2 10%;	*[g/s]*	*412*	*560*	*736*	*968*
Volume flow	Q_{W45}; W 45; O_2 10%; 150°C	*[m³/s]*	*0.50*	*0.67*	*0.88*	*1.15*
Average exhaust gas temperature at Q_N *6)*		*[°C]*	*160*			
Average exhaust gas temperature at Q_{min} *6)*		*[°C]*	*120*			
Chimney draught required		*[Pa]*	*+-0*			
Electrical connections						
Electrical connections (Σ boiler plant)		*[kW]*	*7.02*	*8.12*	*9.35*	*11.15*
Ignition device		*[kW]*	*1.6*			
Exhaust gas fan		*[kW]*	*1.1*	*2.2*	*2.2*	*4.0*
Feed auger		*[kW]*	*1.5*	*1.5*	*2.2*	*2.2*
Primary airflow fan 1		*[kW]*	*0.3*	*0.3*	*0.48*	*0.48*
Primary airflow fan 2		*[kW]*	*0.9*			
Secondary airflow fan		*[kW]*	*1.5*	*1.5*	*1.85*	*1.85*
Grate drive unit		*[kW]*	*0.12*			
Electric power consumption at Q_N		*[kW]*	*3.57*	*4.56*	*5.17*	*6.79*
Electric power consumption at Q_{min}		*[kW]*	*2.9*	*3.71*	*4.15*	*5.47*
Heating-relevant specs						
Volume on heating gas side		*[l]*	*2280*	*2830*	*4050*	*5210*
Volume of ash container for grate ash		*[l]*	*240 / 800*			
Volume of ash container for exhaust gas de-duster		*[l]*	*240 / 800*			
Water-bearing resistance (Diff. 15 K)		*[mbar]*	*23*	*43*	*26*	*45*
Boiler water volume		*[l]*	*1444*	*1861*	*1943*	*2482*
Heating surface		*[m²]*	*42.50*	*55.50*	*74.80*	*91.00*
Test pressure		*[bar]*	*7,8*			
Maximum operating pressure		*[bar]*	*6*			
Maximum boiler temperature		*[°C]*	*100*			
Minimum return temperature		*[°C]*	*65*			
Weights						
Weight of fire block		*[kg]*	*3833*	*4665*	*5892*	*7252*
Weight of heat exchanger		*[kg]*	*1986*	*2562*	*4128*	*5431*
Weight of exhaust gas de-duster		*[kg]*	*463*	*463*	*695*	*695*
Weight of feed auger		*[kg]*	*126*	*126*	*148*	*148*
Total weight without water 7)		*[kg]*	*6802*	*8210*	*11401*	*14064*
Total weight with water 7)		*[kg]*	*8246*	*10071*	*13344*	*16546*

1)	*Continuous output:*	*Output levelling out as base load boiler in continuous operation with pneumatic cleaning system (for track time, see Operating Instructions)*
2)	*$Q \geq Q_{min}$:*	*Operation with modulated control*
	$Q \leq Q_{min}$:	*Low load with ON Q_{min} / ember maintenance operation*
3)	*Efficiency:*	*Specification with displacement rods and flue gas recirculation system* *for dry fuels (W5 to W20) without flue gas recirculation system-reduced values*
4)	*Wet fuels:*	*>W45 further restrictions in terms of output, efficiency and control behaviour*
5)	*Specification:*	*See Spec Sheet 1010, Minimum Requirements for Wooden Fuels*
6)	*Exhaust gas temperature:*	*A reduction is possible by installing the displacement rods (Q_N - 20°C; Q_{min} – 10°C)*
	Other influences:	*fuel water content, ash content, pneumatic cleaning system yes/no, track time (number of operating hours without cleaning) Specifications for the start of the track time (toward the end of the track time there is an increase in the exhaust gas temperature by approx. +15°C)*
7)	*Total weight:*	*incl. displacement rods*

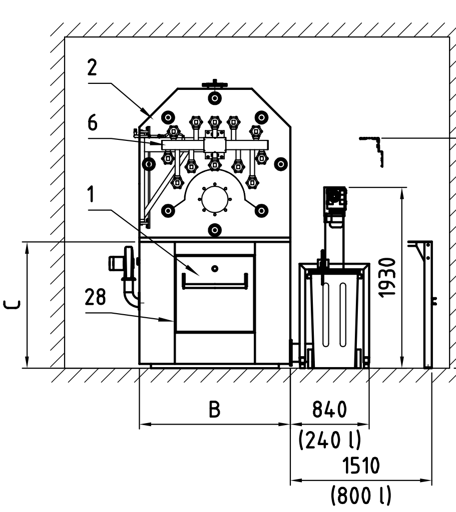
Spec Sheet

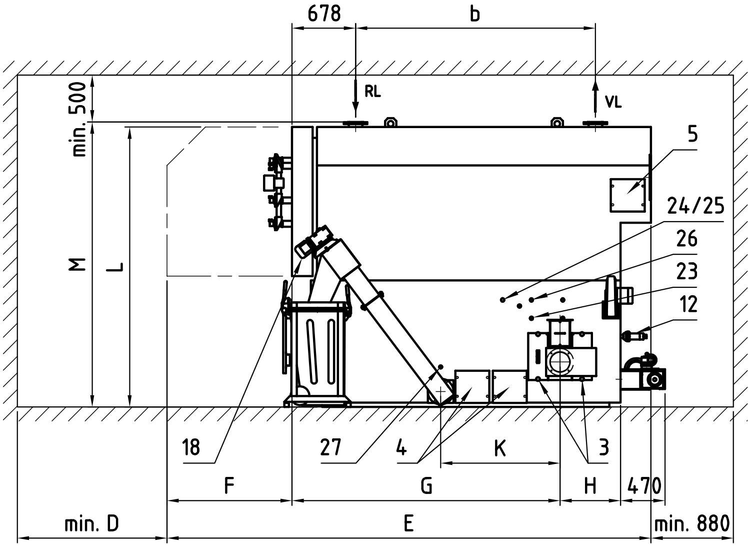
PYRTEC Grate Firing System
Boiler Plant

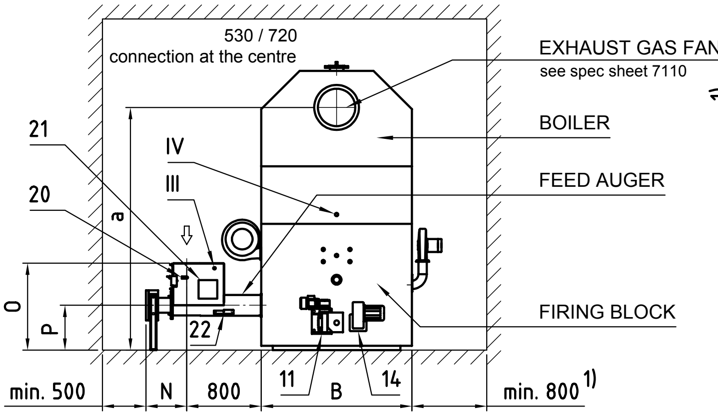
7010-3

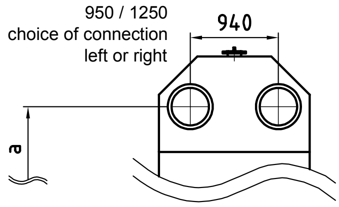
2006-02-01_E

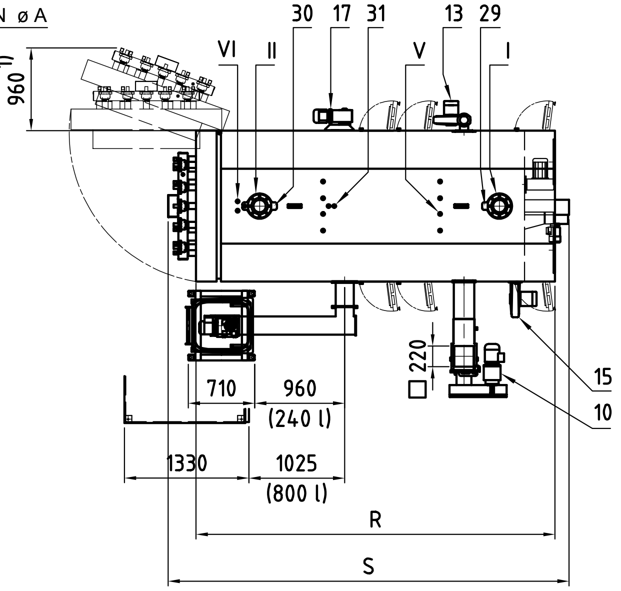
Dimensional drawing:







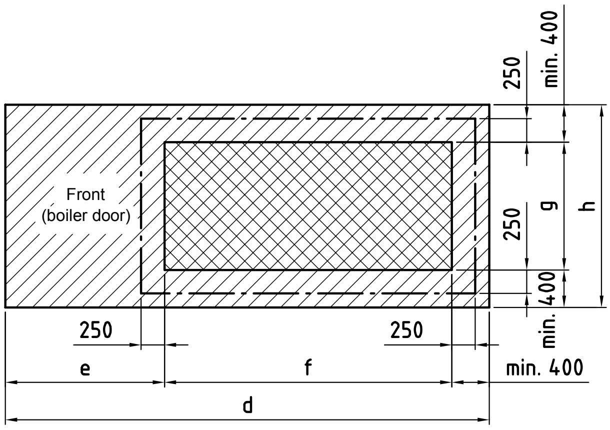




▩ Boiler bearing surface

▨ Floor with heat-resistant design additional

┌·─·┐ The floor construction has to be free of any pipes or installation lines! Danger through the effects of heat!



1) 800 mm access, firing block
960 mm if there is a door stop & pneum. cleaning system
Position of approx. 110° required for manual cleaning of heat exchanger

Spec Sheet

PYRTEC Grate Firing System Boiler Plant

7010-4

2006-02-01_E

Connections/dimensions:

PYRTEC [Item no.]			***KPT-530***	***KPT-720***	***KPT-950***	***KPT-1250***
Water connections PN 6 (see Spec Sheet 7960)						
I	*Boiler forward flow*		*DN 100*	*DN 100*	*DN 125*	*DN 125*
II	*Boiler return flow*		*DN 100*	*DN 100*	*DN 125*	*DN 125*
III	*Connection for extinguishing water*		*R ¾“ AG*	*R ¾“ AG*	*R ¾“ AG*	*R ¾“ AG*
IV	*Drain valve for boiler*		*R 1 ½“IG*	*R 1 ½“ IG*	*R 1 ½“ IG*	*R 1 ½“ IG*
V	*Safety heat exchanger*		*4 x R ½“ AG*	*8 x R ½“ AG*	*8 x R ½“ AG*	*8 x R ½“ AG*
VI	*Dipping shell for thermal run-off safety valve*		*1 x R ½“ IG*	*2 x R ½“ IG*	*2 x R ½“ IG*	*2 x R ½“ IG*
Connection for exhaust gas pipe Ø [mm]		*A*	*350*	*350*	*450*	*450*
Location of the connections [mm]		*a*	*2359*	*2491*	*2444*	*2639*
		b	*1922*	*2562*	*2562*	*3107*
Dimensions of the foundations [mm]		*d*	*4272*	*4912*	*5096*	*5641*
		e	*1400*	*1400*	*1630*	*1630*
		f	*2472*	*3112*	*3066*	*3611*
		g	*1112*	*1112*	*1360*	*1360*
		h	*1912*	*1912*	*2160*	*2160*
Dimensions of the boiler [mm]		*B*	*1380*	*1380*	*1612*	*1612*
		C	*1283*	*1413*	*1371*	*1566*
		D	*760*	*1430*	*1050*	*1550*
		E	*4617*	*5257*	*5447*	*5992*
		F	*1380*	*1380*	*1612*	*1612*
		G	*2353*	*2993*	*2861*	*3406*
		H	*577*	*577*	*657*	*657*
		K	*1200*	*1200*	*1275*	*1275*
		L	*2654*	*2784*	*2981*	*3176*
		M	*2702*	*2834*	*3035*	*3230*
		N	*308*	*308*	*440*	*440*
		O	*803*	*803*	*929*	*929*
		P	*453*	*453*	*479*	*479*
		R	*3237*	*3877*	*3835*	*4380*
		S	*3794*	*4434*	*4392*	*4937*

Parts for maintenance			
1	*Fire box door with solid double hinging*		
2	*Boiler door*		
3	*Cleaning lid for burner trough*		
4	*Cleaning lid for external grate*		
5	*Cleaning lid for heat exchanger*		
6	*Pneumatic cleaning system*	*Item KPT-W…-S*	*Spec Sheet 7120*
Electric drives; ignition			
10	*Feed auger*		
11	*Drive for feed grate*		
12	*Ignition device*		
13	*Primary airflow fan 1*		
14	*Primary airflow fan 2*		
15	*Secondary airflow fan*		
16	*Exhaust gas fan*	*Dimensions:*	*/ Spec Sheet 7110*
17	*De-ashing, fire box auger*	*Item KPT-A.-S*	*/ Spec Sheet 7120*
18	*De-ashing, ascending conveyor auger*	*Item KPT-A.-S*	*/ Spec Sheet 7120*
Switches and sensors	*These items are part of the Pyrocontrol control system*	*Item PYR-…*	*/ Spec Sheet 7800*
20	*Light barrier for feed auger*		
21	*Limit switch for maintenance cover*		
22	*Temperature sensor for feed auger*		
23	*Light barrier for embers*		
24	*Fire box temperature sensor (insertion side)*		
25	*Negative pressure sensor (opposite insertion side)*		
26	*Overpressure monitor for fire box*		
27	*Light barrier for de-ashing*		
28	*Limit switch for fire box door*		
29	*Boiler sensor*		
30	*Return flow sensor*		
31	*Temperature-limiting safety switch (TLSS)*		
32	*Exhaust gas sensor*	*Location:*	*Spec Sheet 7110*
33	*Lambda sensor with measuring transducer*	*Location:*	*Spec Sheet 7110*

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Hopper/Wet Holding--|--Farm Bins --|--4" Stiffened Bins --|--Commercial Bins --|--Commercial Hopper Tanks --|--Top Dry

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NCHT Series Specifications (2.66" Corrugation)

FCHT Specifications - 4.00" Corrugated Sidewall

45 Degree Hopper FCHT's = 18' Dia. | 21' Dia. | 24' Dia.

Series	Max Bu. Capacity	Eave Height (Feet)	Peak Height (Feet)	Capacity (Cubic Feet)	Hopper Clearance	Metric Tons 800 kg/m^3	Metric Tons 721 kg/m^3	Metric Tons 640 kg/m^3	Eave Height (Meters)	Peak Height (Meters)	Maximum Capacity (Cubic Mtrs.)
FCHT18-345F	3371	22'-3"	26'-11"	3956	32"	96	86	76	6.78	8.20	112
FCHT18-445F	4157	25'-11"	30'-7"	4880	32"	118	106	94	7.90	9.33	138
FCHT18-545F	4943	29'-7"	34'-3"	5804	32"	140	126	112	9.02	10.44	164
FCHT18-645F	5730	33'-3"	37'-11"	6727	32"	162	146	129	10.13	11.56	190
FCHT18-745F	6516	36'-11"	41'-7"	7650	32"	185	166	148	11.25	12.68	217
FCHT18-845F	7303	40'-7"	45'-3"	8573	32"	207	186	165	12.37	13.79	243
FCHT18-945F	8089	44'-3"	48'-11"	9496	32"	229	206	183	13.49	14.91	269
FCHT21-345F	4811	23'-7"	29'-2"	5648	32"	136	121	109	7.20	8.89	159
FCHT21-445F	5881	27'-3"	32'-10"	6904	32"	166	149	133	8.31	10.01	195
FCHT21-545F	6951	30'-11"	36'-6"	8160	32"	196	177	157	9.42	11.13	231
FCHT21-645F	8021	34'-7"	40'-2"	9417	32"	227	204	182	10.54	12.24	267
FCHT21-745F	9092	38'-3"	43'-10"	10674	32"	257	231	205	11.66	13.36	302
FCHT21-845F	10162	41'-11"	47'-6"	11930	32"	287	258	230	12.78	14.48	338
FCHT21-945F	11232	45'-7"	51'-2"	13187	32"	317	285	254	13.89	15.60	373
FCHT24-445F	7971	28'-3"	34'-9"	9358	32"	225	203	180	8.61	10.60	265
FCHT24-545F	9369	31'-11"	38'-5"	11000	32"	264	238	211	9.73	11.71	311
FCHT24-645F	10767	35'-7"	42'-1"	12641	32"	304	274	243	10.85	12.83	358
FCHT24-745F	12165	39'-3"	45'-9"	14282	32"	343	309	275	11.96	13.95	404
FCHT24-845F	13563	42'-11"	49'-5"	15923	32"	383	345	306	13.08	15.06	451
FCHT24-945F	14961	46'-7"	53'-1"	17565	32"	422	380	338	14.20	16.18	497

Cubic Meters based on 28 degree angle of repose.
Specifications and design are subject to change without notice.
All commercial bins are designed for the storage of grain and other free-flowing materials weighing up to 52 lbs. per cubic foot.
Maximum bushel capacity based on 6% compaction.
Maximum storage capacities reflect grain peaked on center, using an agnle of repose of 28 degrees.
Other ring heights for 30 degree slope roofs.
Peak heights shown for 30 degree slope roofs.

Typical Grain Densities:
Wheat approximately 800 kg/m^3 (50 lb/ft^3);
Corn approximately 721 kg/m^3 (45 lb/ft^3);
Rice approximately 640 kg/m^3 (40 lb/ft^3);

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CHT Specifications | CHT Roofs | Easy Tank Access | Grain Aeration/Conditioning

Hopper/Wet Holding | Farm Bins | 4" Stiffened Bins
Commercial Flat-Bottomed | CHT | Top Dry

Grain Storage | Grain Drying and Conditioning | Material Handling
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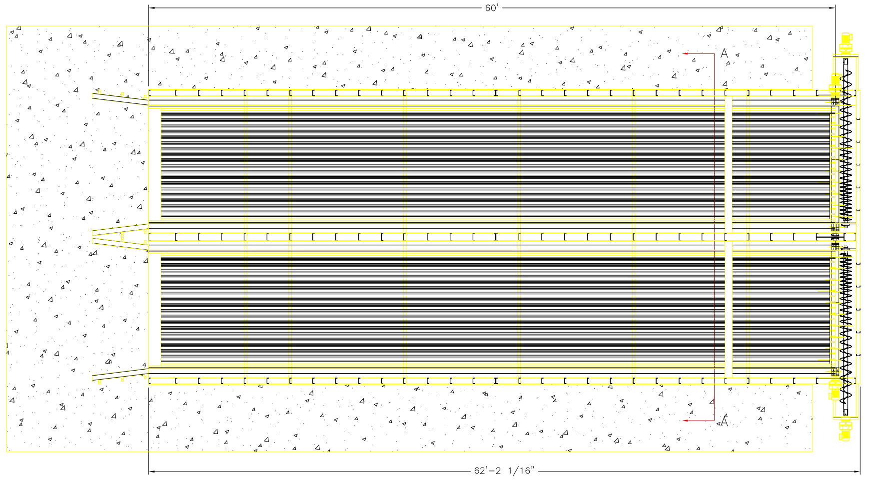
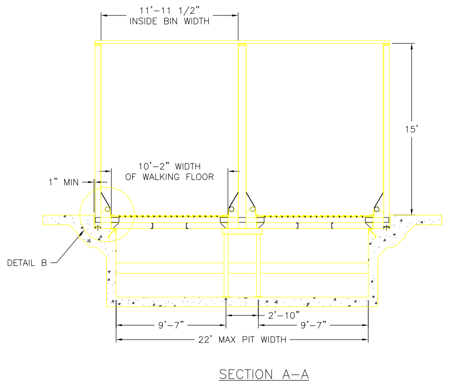
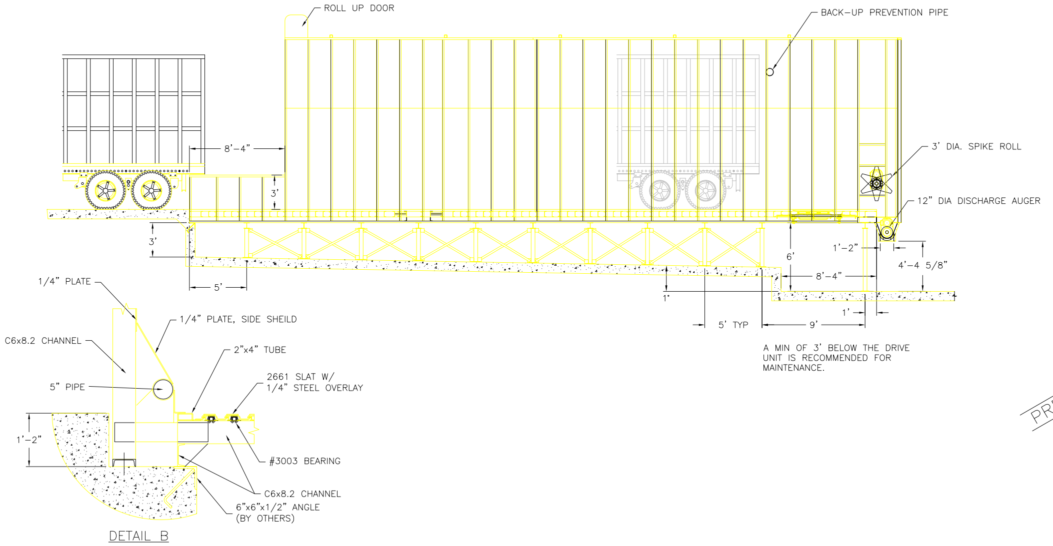


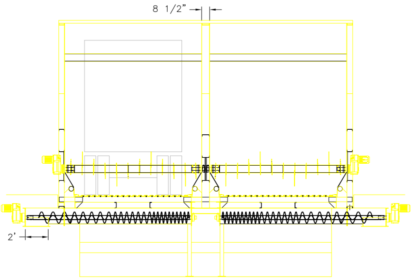


SECTION A-A



A MIN OF 3' BELOW THE DRIVE UNIT IS RECOMMENDED FOR MAINTENANCE.

DETAIL B



PRELIMINARY ONLY

KEITH MFG. CO.
P.O. BOX 1, MADRAS, OR 97741
PHONE: 541-475-3802, NAT: 800-547-6161, FAX: 541-475-2169

IT IS THE CUSTOMERS RESPONSIBILITY TO CHECK FOR, AND ADVISE OF ANY POSSIBLE INTERFERENCE BETWEEN EXISTING OR FUTURE INPLANT COMPONENTS AND THE ITEMS PROPOSED BY K.M.C. ON THIS PRINT

SCALE: 1:50
DATE: 6/1/2009
APPROVED BY:
DRAWN BY JJS
REVISED

TOLERANCE UNLESS OTHERWISE NOTED
FRACTIONS ± 1/32"
ANGLES ± .5
DECIMALS ± .016"
SHAFT DIA. ± .005"

(2)12'x60' BUNKER, KRFII 3 1/2", 40 TON RATING, 2661 SLAT W/ 1/4" STEEL OVERLAY, SHOP DRAWING

TRANSCO NORTHWEST – 5-28-09

DRAWING NUMBER
D-66232

CERTIFICATE OF ANALYSIS

PINNACLE PELLET INC.
4252 Dog Prairie Road
Quesnel, BC V2J 6K9

May 7, 2007

CERTIFICATE OF ANALYSIS

Date: May 7, 2007

VESSEL : M.V. " STAR ISTIND"
COMMODITY DESCRIBED AS : WOOD PELLETS, in bulk
LOADING DETAILS : 7,005.00 Metric Tons loaded to Nos. 4 and 5 Holds on May 3, 2007 at Fibreco Terminal Ltd., Port of Vancouver, British Columbia, Canada

Our ref: 203-

ANALYSIS		**AS RECEIVED BASIS**	**DRY BASIS**
Total Moisture	%	**4.87**	xxxx
Ash	%	xxxx	**0.30**

PARAMETER	**MEASURE**	**VALUE**
Hydrogen, (dry basis)	% of weight	**6.14**
Nitrogen, (dry basis)	% of weight	**0.08**
Oxygen, (dry basis)	% of weight	**43.33**
Carbon (dry basis)	% of weight	**50.14**
Sulphur (dry basis)	% of weight	**0.01**

CALORIFIC VALUE (ISO 1928)	**MJ/kg**	**Kcal/kg**	**MWh/tonne**	**BTU/lb**
Net Calorific Value at Constant Pressure, including moisture (as received basis)	**18.14**	**4335**	**5.04**	**7799**
Net Calorific Value at Constant Volume, including moisture(as received basis)	**18.21**	**4353**	**5.06**	**7831**
Net Calorific Value at Constant Pressure (dry basis)	**19.19**	**4587**	**5.33**	**8252**
Net Caloriic Value at Constant Volume (dry basis)	**19.26**	**4604**	**5.35**	**8283**

This analysis is based on samples submitted to the laboratory of SGS Canada Inc., Minerals Services.

M. Bryan, Laboratory Manager

Dry Electrostatic Precipitators

for Flue Gas Dedusting

scheuch
TECHNOLOGY FOR CLEAN AIR

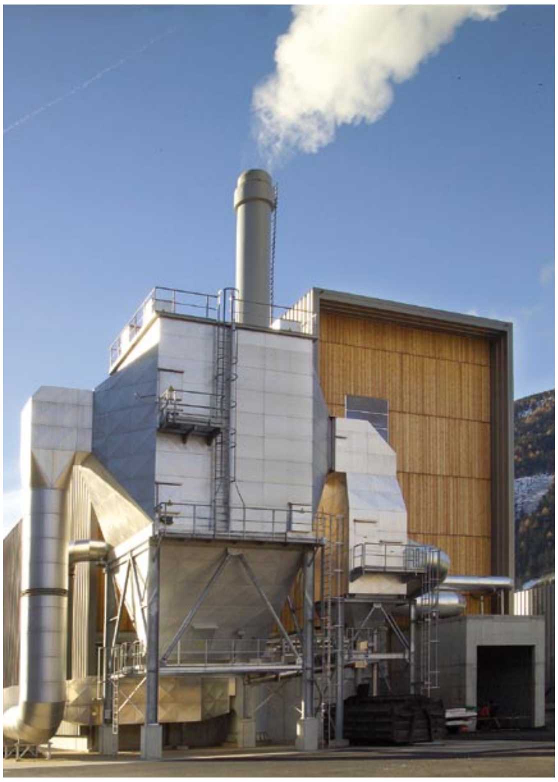
OVERALL KNOW-HOW MAKES THE DIFFERENCE

Scheuch has extensive know-how in filtration technology, including practical experience with thousands of filtration plants in operation around the world in different industrial sectors.

Depending on the application, we offer a variety of processes and system combinations for dust removal:

- Centrifugal separators for pre-separation
- Electrostatic precipitators
- Fabric filters supplemented with sorption-based processes for additional removal of pollutants
- Flue gas condensation plants for heat recovery (ERCS)

All filtration technologies are based on Scheuch's own development work and are protected by patents with respect to their most important functional aspects.



We have for many years placed special emphasis on the optimization of individual machines and components with respect to their efficiency. An integrated view of the overall plant (including, for example, incoming flow, flow distribution in the equipment, pipe layout) is an essential prerequisite for improved process adaptation and the lowest possible life cycle costs.

Range of Application: Flue Gas Dedusting

We primarily use dry electrostatic precipitators to dedust the flue gases generated by biomass-fired boiler installations. In contrast to fabric filter systems, the electrostatic precipitator (ESP) is especially reliable in this role because it is relatively insensitive to the entry of sparks and because it tolerates boiler load fluctuations extremely well.

Advantages of the Dry Electrostatic Precipitator

- Hot gas resistant (up to 300° C in standard versions with special temperature-dependent designs for higher temperatures)
- High separation efficiency (Separation rates of more than 99%)
- Insensitive to load fluctuations, flying sparks, overheating and sporadic undershooting of the dew point)
- Low operating costs because of a low level of pressure loss (resulting in a reduction in fan power consumption) and low maintenance costs (no replacement filter bags)
- Long service life and high operational availability
- Low retrofit costs at any time because the low level of pressure loss makes it unnecessary to adapt equipment
- Low noise emissions

PROPER DESIGN AND DIMENSIONING DETERMINE EFFICIENCY

The design of electrostatic precipitators used to clean flue gases generated by biomass-fired combustion processes requires substantial process know-how because many parameters must be considered. On the one hand, consideration must be given to flue gas parameters that have a direct influence on the separation efficiency and also to ash composition. On the other hand, the basic process conditions must also be considered. The proper assessment of the advantages and disadvantages of different technologies or combinations of technologies, e.g., downstream heat recovery systems, makes it possible to achieve the optimal customer-specific solution.

Flue gas

Volume flow
Temperature, pressure
Flue gas moisture
Composition
($O_2/CO_2/CO/SO_X$)
Load conditions

Dust

Crude gas dust load
Clean gas dust load
Distribution of grain sizes
Chemical analysis
Dust resistance

Design

Machine geometry
Gas distribution
Number of fields
Thickness of insulating material

High Voltage System

Type – Design
High voltage control system
Power output control system

The advantages of Scheuch's dry electrostatic precipitators include

Low investment costs

- High separation efficiency
- Compact design
- Optimal incoming flow and gas distribution
- Customer-specific design (system combinations with pre-separator)
- Modular design principle with high degree of pre-assembly

Low operating costs

- Low level of pressure loss
- Real-time digital control system
- Boiler-dependent adjustment of high-voltage power (partial load operation)
- High-voltage power control via dust measurement

High operational availability

- All components developed in-house
- High quality through in-house manufacturing
- Comprehensive maintenance concept

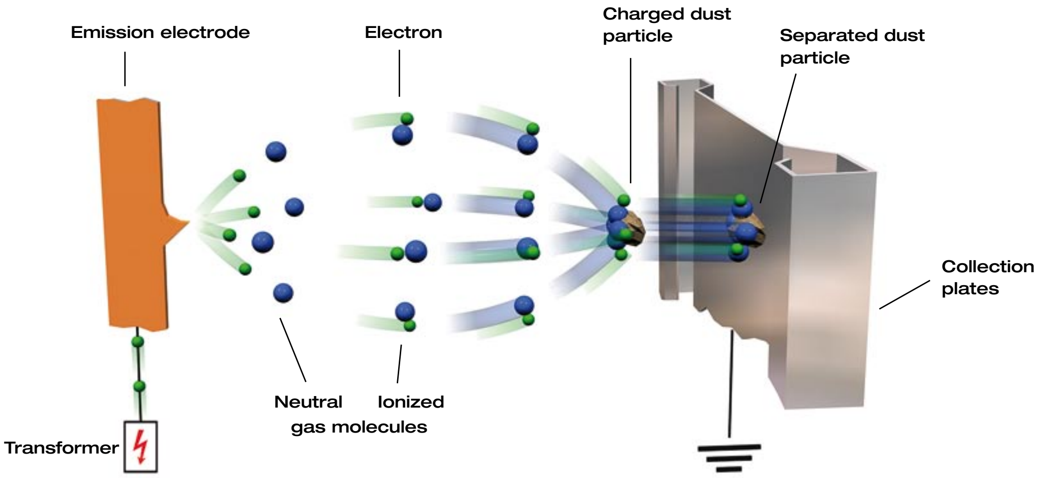
Single Source Solution

Especially noteworthy is the fact that, in addition to the individual components of the ESP, the complete materials handling technology (discharge devices) as well as other components, including cyclones and fans, are also developed and manufactured in-house and adapted to specific plant configurations. The overall implementation — which occurs without interface problems — as well as additional system combinations, including our heat recovery system, makes an important contribution to a high level of plant efficiency for the operator.

THE PRINCIPLE OF ELECTROSTATIC PRECIPITATION

Particle Charging

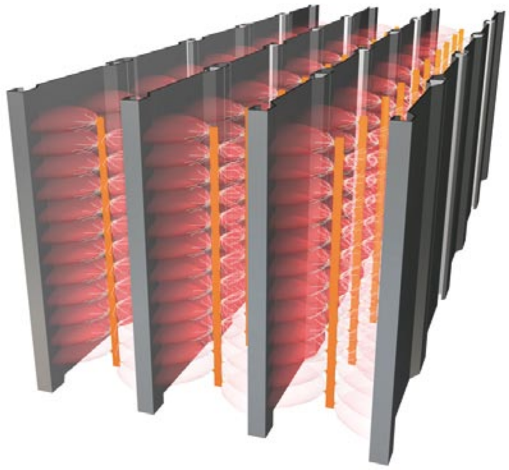
Particle separation in the electrostatic precipitator is based on the principle of electrostatic precipitation. Electrons are emitted by a negatively charged emission electrode and then accelerated towards a positively charged collection electrode. The accelerated electrons or contact with the gas ions causes dust particles flowing through the filter to become negatively charged and subsequently move towards the positively charged collection electrode.

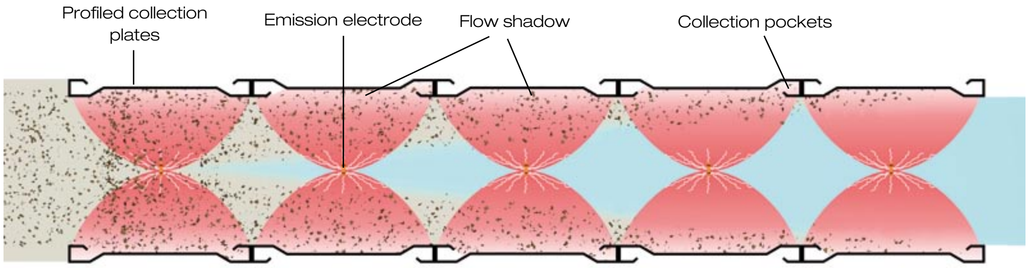


Particle Separation

The dust that collects on the profiled collection electrodes is periodically cleaned by a tap-off mechanism and is thus removed from the gas stream. The formation of so-called collection pockets on the collection electrodes prevents the re-entrainment of particles that have already been separated from the gas stream.

Electrostatic precipitators are therefore extremely well suited for separating fine dust from gas flows.





KEEPING TECHNOLOGY ON THE MOVE

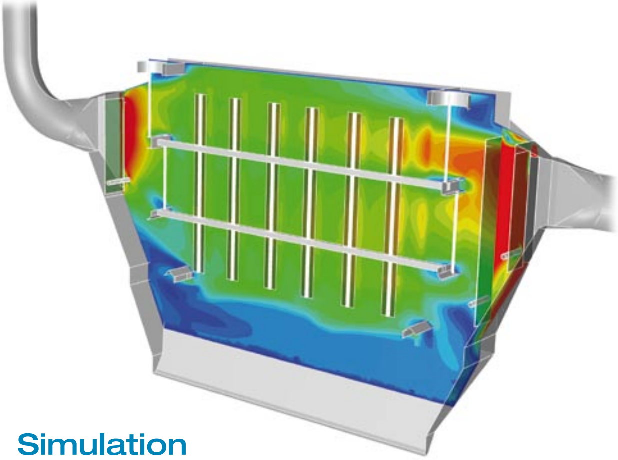
In order to further improve the state of this technology, we have a strong focus on research and development projects. For example, testing conducted at our in-house Technikum, or Tech Center, helps us to better understand the processes that take place in the separation zone of dry ESPs. Our development work is constantly focused on such themes as flow distribution, electrode geometry, different particle types and dust characteristics, high voltage supply, cleaning systems and re-entrainment, as well as mechanical construction and dust discharge.

Operational Data for Research and Development

Operational data logging and plant measurements ensure verified scale-up to industrial standards. Through follow-on testing in our in-house laboratory, we are able to support customers in the event of problems and optimize plants and equipment onsite. If, for example, clean gas dust levels are continuously measured, an energy optimization program can be installed to reduce power input during periods of partial load operation. This reduces operating costs and saves electrical energy.

Flow Optimization to Improve Efficiency

Uniform flow distribution in the separation zone of an electrostatic precipitator is a decisive criterion for best possible operation. In addition, bypass flows must be avoided and dust re-entrainment must be minimized during the tap-off process. For this reason, Scheuch has already worked for a number of years with CFD software - CFD is an acronym for Computational Fluid Dynamics - that offers opportunities for flow optimization based on this computational method. Further, this method makes it possible to more and more precisely predict particle paths inside the ESP and the flow distribution in the electrical field.



Simulation and Specification

As the result of intensive development work in this area, Scheuch is now able to simulate complete electrostatic precipitators during the planning phase. Cost-intensive and time-consuming model building and measurements in our own Tech Center are not necessary for most applications. This tool makes it possible to take into account unfavorable incoming flow situations for electrostatic precipitators and to compensate for them by selecting appropriate guide and distribution devices. This benefits the customer by making it possible to include the ESP unit in the overall plant in a way that is more precise and that usually saves space.

Highly Cost-Effective Thr

Grounding accessories including tools attached to safety rail

Hermetically sealed transformers

Thermal insulation prevents dew point undershooting and protects against accidental contact

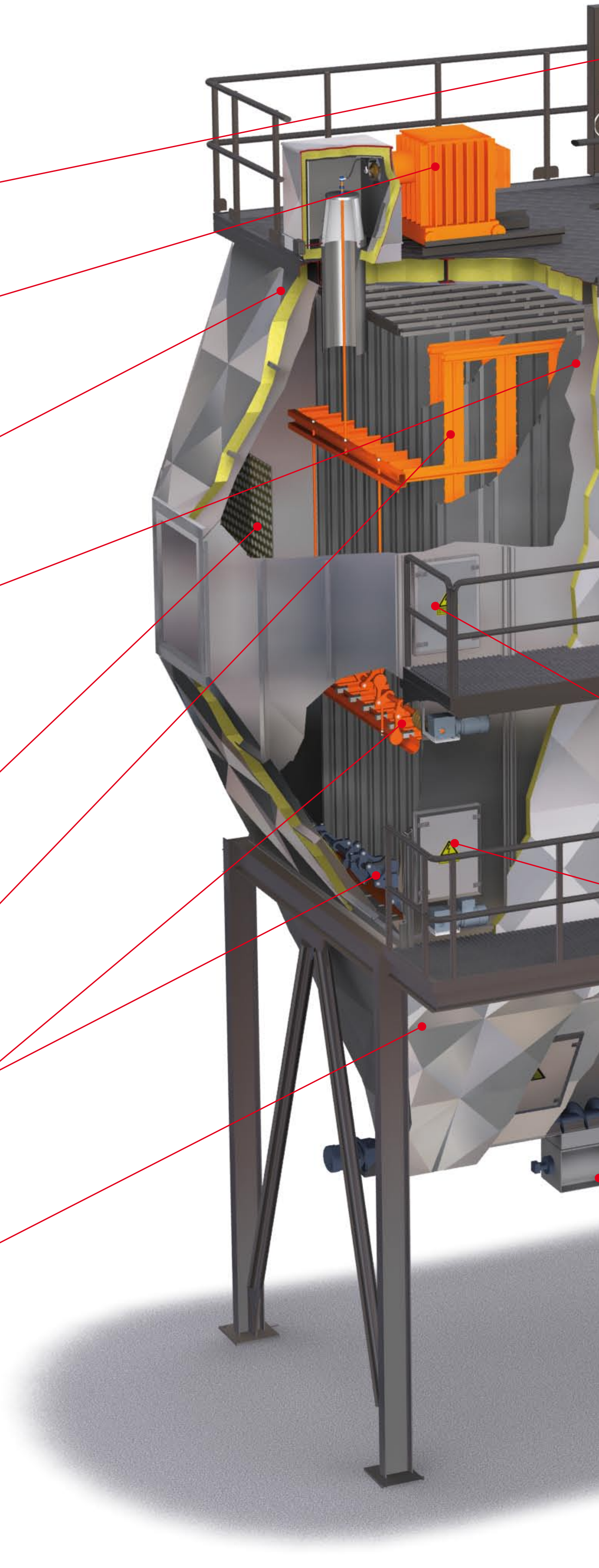
Profiled collection electrodes ensure excellent and reliable dust separation

Several rows of perforated plate ensure optimal gas distribution with minimal pressure losses, as these perforated plates exhibit a very low resistance value

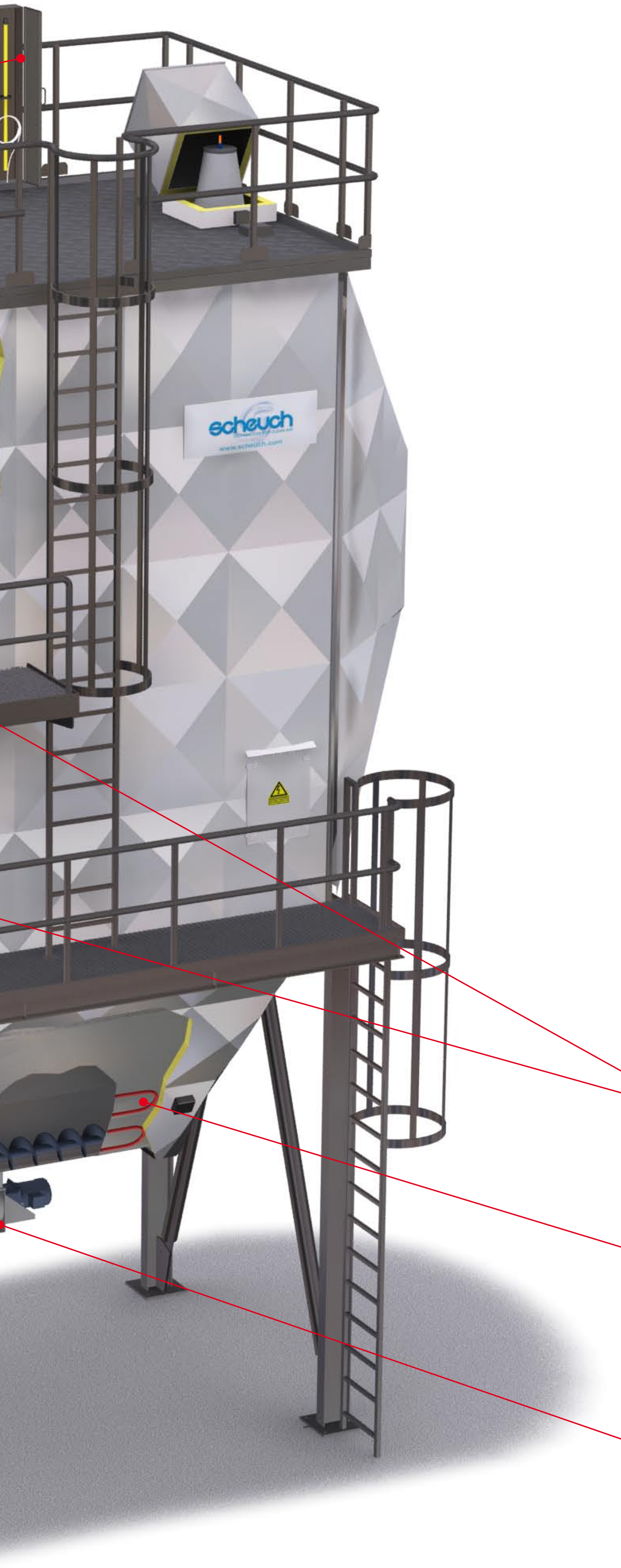
Specially designed emission electrodes ensure high separation efficiency

Tap-off mechanism: Cleaning of the collection and emission electrodes occurs periodically using tap-off hammers

Dust collection basins with an adequate angle of inclination reduce the risk of caking; discharge screws ensure problem-free discharge of dust



ROUGH MATURE TECHNOLOGY



Function

The dust-laden gas enters the filter horizontally, passing over gas distribution plates before being evenly distributed through a number of street-like “channels” formed by the walls of the grounded collection electrodes.

Located in the middle of each channel are emission electrodes, which have a high negative charge and which ionize the gas through a corona discharge. As the gas flows through the filter, the dust particles are negatively charged when they make contact with the gas ions and subsequently collect on the positively charged collection electrodes. The layer of dust that collects on these electrodes is periodically dislodged by a tap-off mechanism. The dust falls into a collection basin and is then removed by a screw conveyor. In order to avoid potential deposits on the emission electrodes, these are also cleaned by a tap-off mechanism.

Generously dimensioned service openings facilitate maintenance access

Self-regulating, electrically powered auxiliary heating prevents dew point undershooting in the ash discharge area

Insulated and heated rotary valves as shutoff device of the filter system

GOOD ACCESSIBILITY FOR LOW MAINTENANCE COSTS

Simple and quickly completed maintenance tasks make a significant contribution to plant availability and have a positive impact on operating costs. This not only saves time and money, but also offers a high safety level for the operator's personnel.

Good Accessibility

Scheuch's dry electrostatic precipitators are designed to provide the best possible access to all relevant maintenance points. They have worker-accessible platforms near the tap-off mechanisms, offer generously dimensioned control doors for side access, and offer adequate clearance for inspection and cleaning of the filter channels, including the ability to remove and remount the gas distribution plates.

Transformer on castors

Simple Maintenance

In addition to providing good accessibility, Scheuch has taken specific steps to facilitate maintenance work by the operator's personnel. Insulators, for example, can be checked from outside and entry into the filter for the purpose of cleaning the insulator interior is not necessary. If necessary, the post insulators can be exchanged with minimum disassembly. The required grounding of the transformer unit takes place via the easily accessed control opening of the high-voltage insulator on the filter roof.

Grounding kit

Safety

With an optional Safety-Key-System, entry into the filter unit and grounding of the transformer can only be undertaken after progressing through a pre-specified safety plan. Each step in the plan can only be completed as a function of the previous step.

SERVICE PAYS OFF IN HIGH PLANT AVAILABILITY

High operational availability of a filtration plant is the fundamental requirement of plant operators. With the know-how of its experts, Scheuch offers modern upgrade and maintenance concepts. Comprehensive measurement processes are used to perform gas and dust analyses, function checks and acoustical analyses as part of an optimal support concept whose goal is the highest possible level of plant availability.

Service Contract

Plant shutdowns are expensive. It is therefore advisable to have inspection and maintenance work performed once each year in order to promptly identify and correct problems. These measures allow us to guarantee the long-term and problem-free function of your filtration plant. We therefore advise customers to sign an inspection and service contract.

Hinged cover for easy access to insulator

Point-by-Point Checklist

We guarantee that your plant will be regularly inspected in accordance with our maintenance instructions. This includes, amongst other things, a functional inspection of the high-voltage supply system, a technical inspection of the plant for functional deficiencies, and functional inspections of the filter cleaning units and discharge system, the monitoring, protection and safety devices, the electrode cleaning system, dust discharge devices and the electrical control system, as well as a detailed inspection of the auxiliary heating equipment and insulators.

Measurement of the dust concentration

Lowest Service Costs

Service appointments are arranged ahead of time so that the customer can also prepare for the appointment (e.g., should it be necessary to cool down the boiler installation or perform cleaning before the service appointment). As a rule, this prevents expensive repairs, unplanned equipment failures and plant downtime.

Upon completion of inspection and maintenance work, the customer receives a report detailing the extent of the work performed and repairs that may be required.

Grounding of insulator

A COMPLETE PROGRAM

The program includes compact filter units that are used for boilers rated at roughly 250 kW and above, system combinations with an integrated pre-separator stage, and combinations consisting of a separate multi-cyclone and dry ESP. Depending on the existing flue gas parameters and basic conditions, these systems use 1-, 2- or 3-field dry electrostatic precipitators.

Scheuch has a carefully tiered modular program with firing thermal capacities ranging from 250 kW to roughly 100 MW, which corresponds to airflows of 1,000 to approximately 500,000 Bm³/h.

COMPACT ESP from 250 kW

ESP with directly attached exhaust stack

ESP with integrated multi-cyclone

ESP with upstream multi-cyclone

FIRING THERMAL CAPACITIES FROM 250 kW TO 100 MW


ESP with attached exhaust stack


ESP with integrated multi-cyclone


Single-field ESP


Single-field ESP with multi-cyclone


2-Field ESP with multi-cyclone


2-Field ESP with ERCS plant


3-Field ESP

TAILOR-MADE SOLUTIONS FOR FLUE GAS CLEANING

With a complete program for dedusting, heat recovery and pollutant reduction, we offer customers tailor-made specialized solutions that perform at the highest technological level with respect to both ecology and energy efficiency.

Bag Filtration Systems

Because of their exceptional filtration performance, fabric filter plants are extremely well suited for filtering fine dust to guaranteed levels of < 3 mg/Nm^3 and for use in combination with sorption-based processes to reduce pollutants.

Sorption Processes

For the energetic utilization of treated and contaminated fuels, as well as waste and residual materials, Scheuch has developed its own adsorption and absorption methods for the cleaning of exhaust gases.

Heat Recovery with ERCS

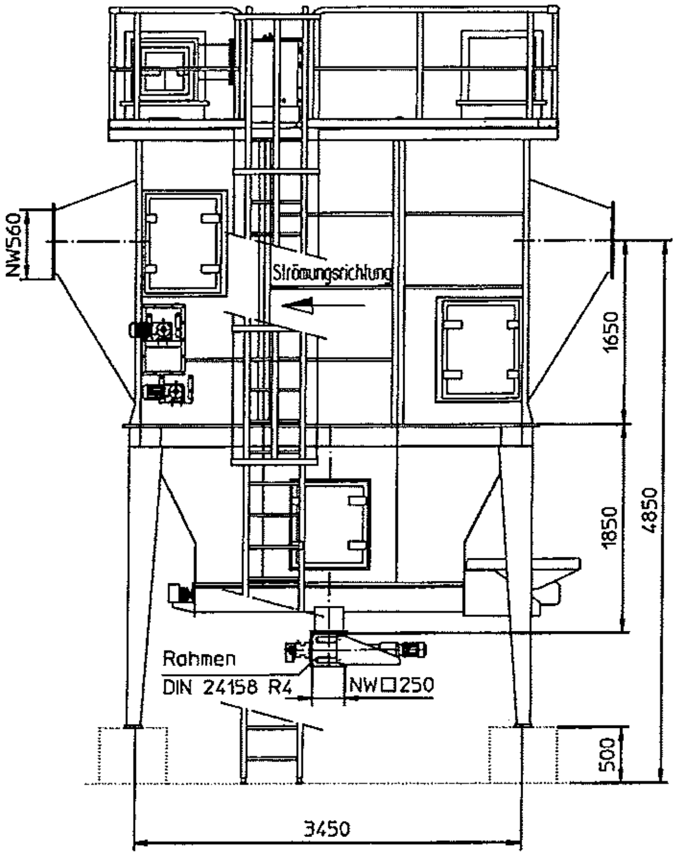
If untreated and wet biomass is used to generate heat and electricity, the use of exhaust gas condensation plants is generally recommended. Our ERCS process (Energy Recovery & Cleaning Systems) offers highly efficient heat recovery and energy-optimized plume removal.

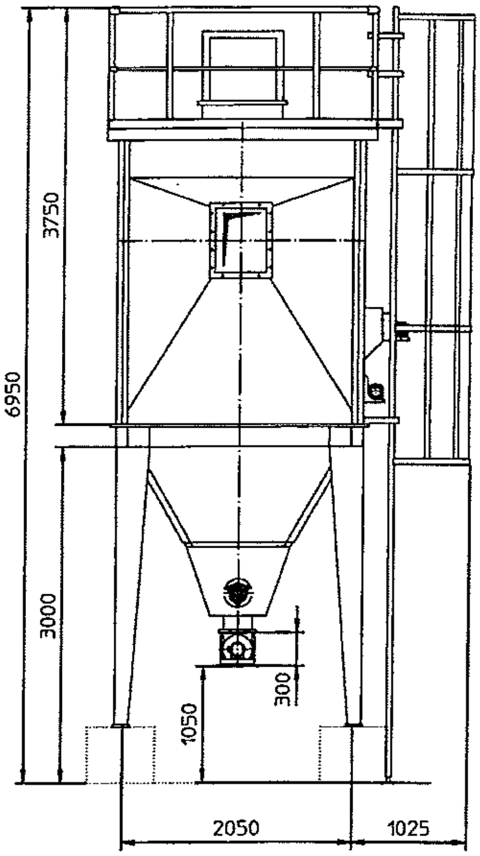
scheuch
TECHNOLOGY FOR CLEAN AIR

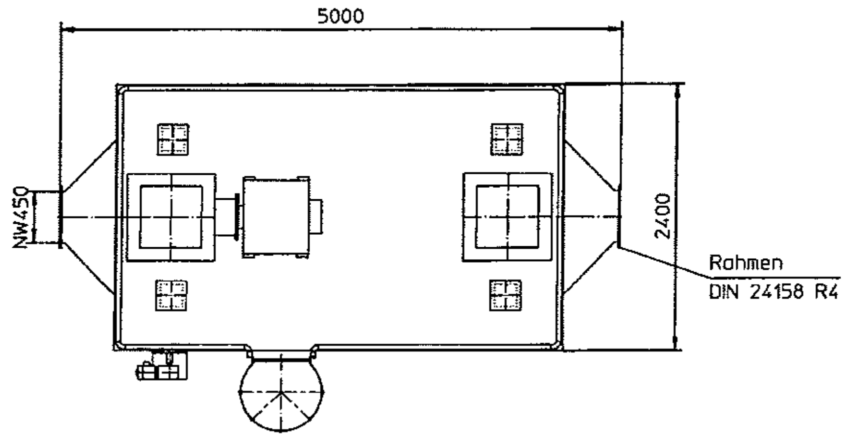
Scheuch GmbH Weierfing 68, A-4971 Aurolzmünster, Tel.: +43/7752/905-0, Fax: -370
office@scheuch.com, www.scheuch.com

Electrostatic filter
sef 2,0/3,4-2,6

Elektrofilter
sef 2,0/3,4-2,6







Tel.:++43/7752/905-0, Fax:-370
A-4971 Aurolzmünster, Weierfing 68

Donaldson®
Torit®

Dalamatic® Dust Collectors

DURA•LIFE™
Twice The Life Filter Bags

Donaldson

Dalamatic®

Proven Performance, Compact Design

The versatile Donaldson® Torit® Dalamatic series of dust collectors deliver a powerful solution for nearly any dust filtration application. These collectors come in two models: the Dalamatic Cased (DLMC) is a stand alone collector that can be ducted to many different applications; the Dalamatic Insertable (DLMV) is a versatile collector that can be inserted into various applications, such as bins, silos, bunkers, storage vessels or transfer points. Both models are continuous-duty dust collectors designed to handle the most difficult product recovery applications.

Dalamatics Offer:

- **Continuous collection** Provides continuous filtration of high dust concentrations at high filtration velocities and constant levels of resistance in almost any industry and application.
- **Compact design** Unique modular design allows for installation in the most space restricted areas. Envelope-shaped bags maximize the amount of media in a given space and allow for increased space between bags, minimizing the chances of bridging.
- **Dura-Life™ Filter Bags** provide better surface loading and better pulse cleaning reducing maintenance and operating costs.
- **Versatility** A full range of sizes and types of bags are available for a wide variety of dust collection applications.
- **10-year warranty**

Simply the Best

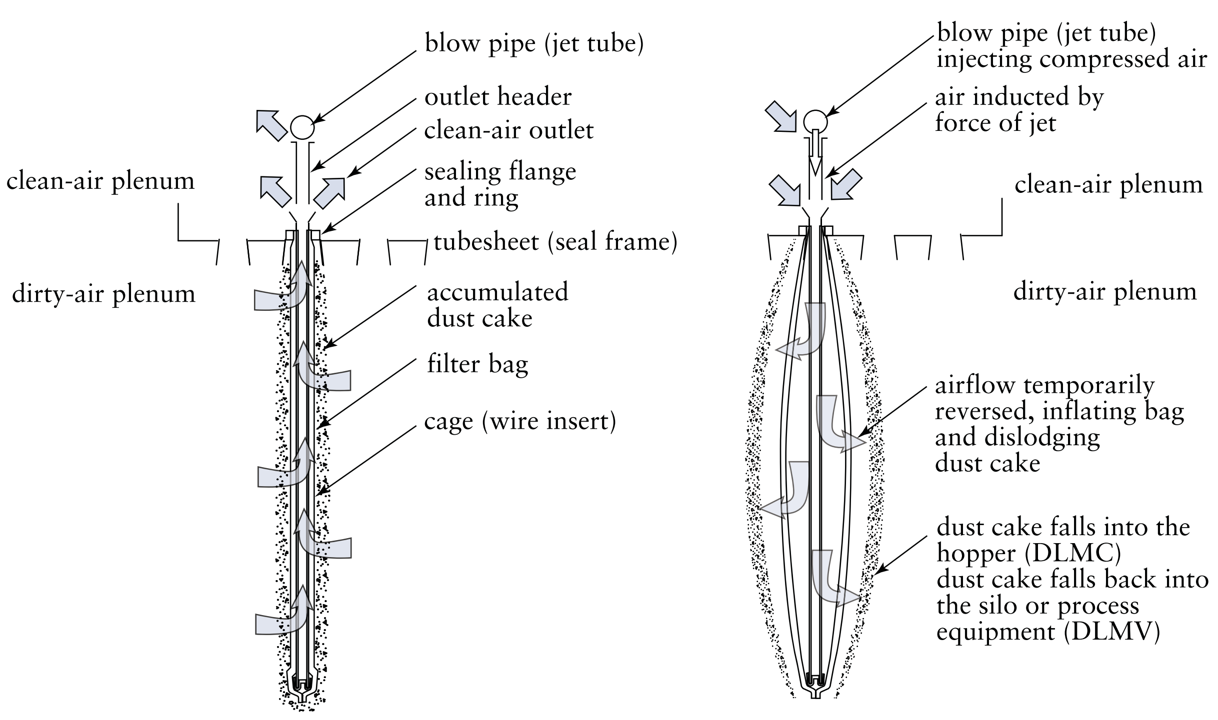
Dust Collectors Available

with Dura-Life™ Twice the Life Filter Bags

DLMC 3/7/15

Flexible, Effective Filter Media

Principles of Filtration



Normal Operation

Filter Cleaning Operation

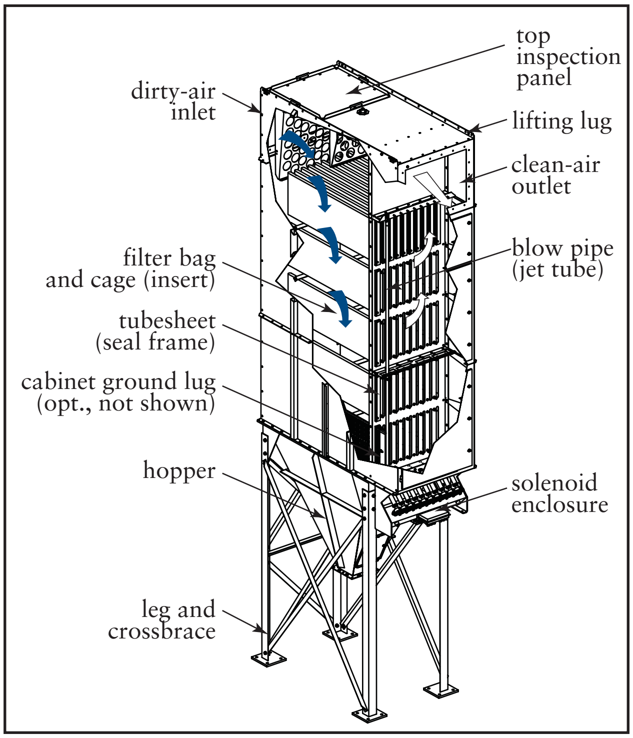
Efficient Media Design The Dalamatic advantage is found in the breakthrough technology of Dura-Life filter bags. Dura-Life bags offer longer bag life and reduced emissions. This unique operation of the filter bag helps achieve high filtration efficiencies.

- Dust accumulates on the outer surface of the filter bag as air penetrates the media.
- The blowpipe (jet tube) injects a burst of compressed air into the filter bag.
- Airflow is then briefly reversed, inflating the filter bag and dislodging dust.
- The dislodged dust cake falls into the collection hopper for final removal or directly back in the the process. The envelope-shaped filter bag, which is mounted on a unique wire frame, ensures optimum airflow and thorough cleaning.

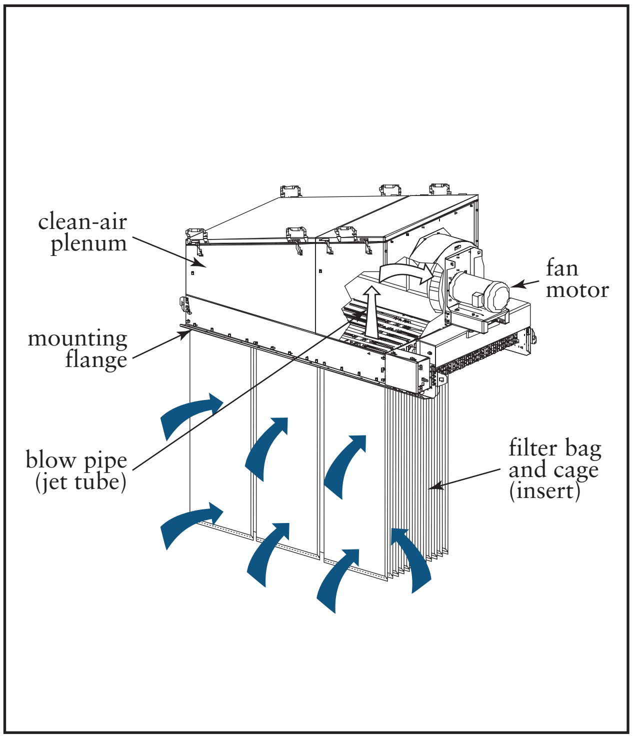
DLMV 45/15

Sizes & Operations

Normal Operation for Models DLMC



Normal Operation for Models DLMV



Dalamatic Cased (DLMC)

- Envelope-shaped bags provide maximum filter area per given space and ensure efficient cleaning
- Air volumes range from 1500 to 85,000 cfm
- Modular design gives dimensional and capacity flexibility
- Downward airflow pattern minimizes dust re-entrainment
- Installed face to face (double-banked) reduces required platforms and ductwork for easy access and maintenance.
- Standard leg pack meets IBC 2003 requirements

Dalamatic Insertable (DLMV)

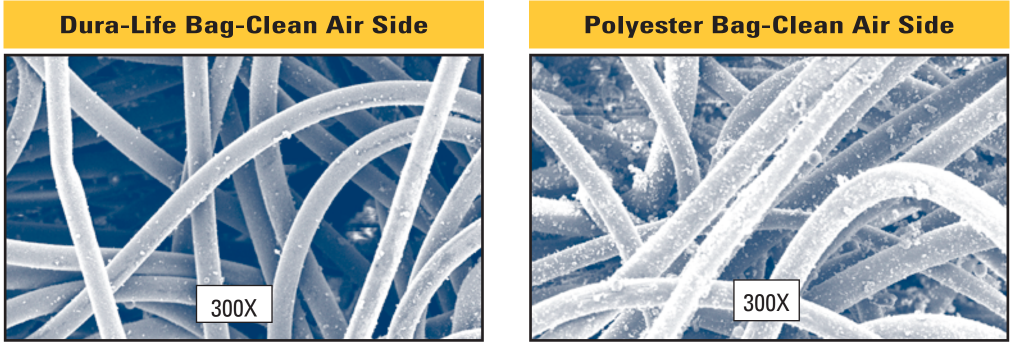
- Five configurations to suit most process applications
- Uses positive pressure of the conveying air or can be fan powered for pneumatic conveying applications
- Bags can be installed hanging vertically, horizontally or any angle in between
- Can be inserted into hood enclosures at belt transfer points, bucket elevator casings, ribbon blenders and receiving hoppers for clamshell unloaders
- Insertable approach reduces or eliminates ducting costs; minimized ducting can also result in reduced energy costs

Dura-Life™ Filter Bag Technology

Standard in All Donaldson Torit Dalamatic Baghouse Collectors

Dura-Life — A technology breakthrough for bag users.

Polyester bags are produced with a needling process that creates larger pores where dust can embed into the fabric, inhibiting cleaning and reducing bag life. Dura-Life* bags are engineered with a unique hydroentanglement process that uses water to blend the fibers. This process provides a more uniform material with smaller pores, better surface loading, and better cleaning. These advantages provide twice the operating life before bags need to be replaced due to high pressure drop. Longer life from Dura-Life bags lowers maintenance and operating costs and raises baghouse dust collection to a whole new level.


Dura-Life Bag-Clean Air Side

Polyester Bag-Clean Air Side

These photos were taken with a scanning electron microscope of bag media used in a collector that was filtering fly ash. The bags were removed after 2,700 hours of use. Air-to-media ratio was 4.5 to 1. Pressure drop was 6 in. on polyester bags and 2 in. on Dura-Life.

Dura-Life bags provide big benefits!

Dura-Life technology provides better surface loading and better pulse cleaning, resulting in:

- **Two to three times longer bag life**
- **Energy savings due to lower pressure drop**
- **Reduced replacement bag costs due to fewer bag changeouts**
- **Reduced maintenance and operating costs due to fewer bag changeouts**
- **30% fewer emissions based on EPA tests**

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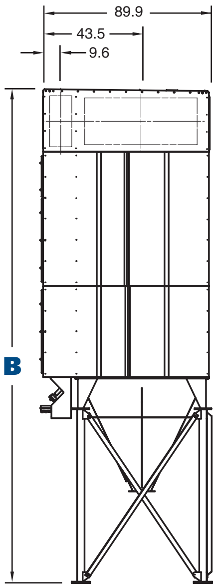
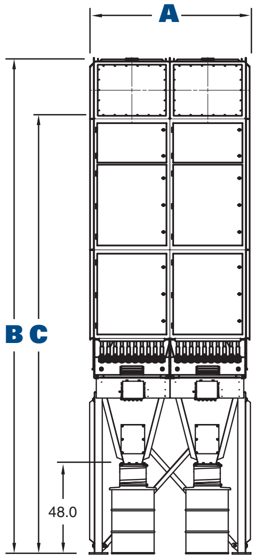
* Dura-Life bags are made with Durapex® filter media manufactured by Polymer Group, Inc.

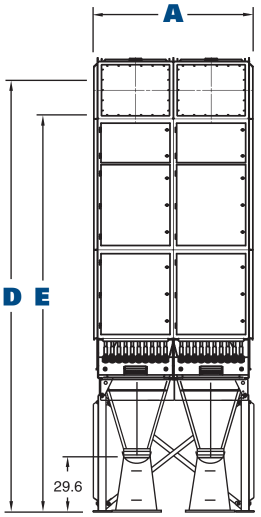
Cased Dimensions & Specifications



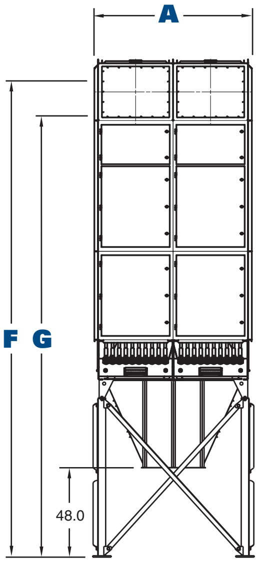
Side View Pyramid Hopper
(2/5/15 Model)



Pyramid Hopper*
(2/5/15 Model)



UMA Hopper
(2/5/15 Model with 4 cu. ft. Bins)



Trough Hopper
(2/5/15 Model)

DLMC Model	Nominal Airflow Range (cfm)**	Cloth Area (ft^2)	No. of Banks	No. of Tiers	No. of Bags	No. of Valves	Shipping Weight (lbs) With Pyramid Hopper	With Hopper for UMA 4 cu. ft. Bin	With Trough Hopper
1/2/15	1,290 - 3,550	323	1	2	20	10	2243	2270	N/A
1/3/15	1,940 - 5,335	485	1	3	30	10	2743	2770	N/A
1/4/15	2,580 - 7,095	645	1	4	40	10	3384	3396	N/A
2/2/15	2,580 - 7,095	645	2	2	40	20	3886	3907	3967
1/5/15	3,240 - 8,910	810	1	5	50	10	3884	3894	N/A
2/3/15	3,880 - 10,670	970	2	3	60	20	4686	4543	4707
1/7/15	4,520 - 12,430	1130	1	7	70	10	5145	4895	N/A
2/4/15	5,160 - 14,190	1290	2	4	80	20	5889	5593	5757
3/3/15	5,815 - 15,990	1454	3	3	90	30	6877	6518	6473
2/5/15	6,480 - 17,820	1620	2	5	100	20	6814	6518	6682
2/6/15	7,750 - 21,315	1938	2	6	120	20	7764	7468	7632
3/5/15	9,690 - 26,650	2423	3	5	150	30	9677	9318	9273
2/8/15	10,335-28,420	2584	2	8	160	20	9289	8993	9157
3/6/15	11,625-31,975	2907	3	6	180	30	11,077	10,718	10,673
4/5/15	12,920-35,530	3230	4	5	200	40	12,670	12,185	11,862
3/7/15	13,565-37,310	3392	3	7	210	30	12,177	11,818	11,773
3/8/15	15,500-42,635	3876	3	8	240	30	13,302	12,943	12,898
4/8/15	20,670-56,845	5168	4	8	320	40	17,445	16,960	16,637

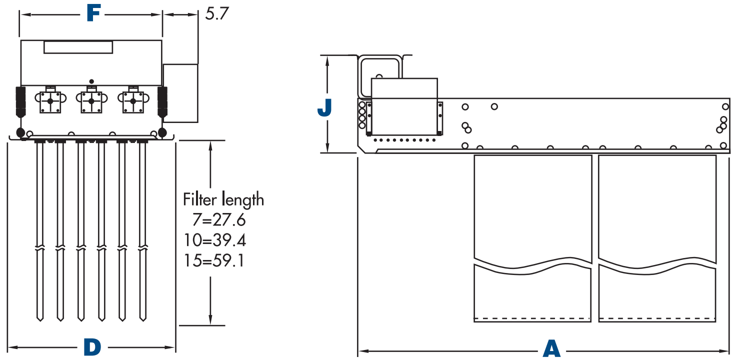
* With optional 55-gallon drum adapter (drum not included).
** Based on clean filters.

Cased Dimensions & Specifications

	Dimensions (inches)						
		Pyramid		UMA		Trough	
DLMC Model	A	B	C	D	E	F	G
1/2/15	43.5	171.7	162.7	147.9	138.9	N/A	N/A
1/3/15	43.5	185.5	194.5	170.7	161.7	N/A	N/A
1/4/15	43.5	216.8	234.2	240.8	193.0	N/A	N/A
1/5/15	43.5	241.6	259.0	235.2	217.8	N/A	N/A
1/7/15	43.5	287.3	304.7	280.9	263.5	N/A	N/A
2/2/15	83.0	171.7	162.7	147.9	138.9	165.7	156.7
2/3/15	83.0	194.5	185.5	170.4	161.7	188.5	179.5
2/4/15	83.0	234.2	216.8	210.4	193.0	228.2	210.7
2/5/15	83.0	259.0	241.6	235.2	217.8	253.0	235.6
2/6/15	83.0	281.9	264.4	258.1	240.7	275.8	258.4
2/8/15	83.0	327.5	310.1	303.7	286.3	321.5	304.1
3/3/15	122.4	194.5	185.5	147.9	138.9	165.7	156.7
3/5/15	122.4	259.0	241.6	235.2	217.8	253.0	235.6
3/6/15	122.4	281.9	264.4	258.0	240.7	275.8	258.4
3/7/15	122.4	304.7	287.3	280.9	263.5	298.7	281.2
3/8/15	122.4	327.5	310.1	303.7	286.3	321.5	304.1
4/5/15	161.9	259.0	241.6	235.2	217.8	253.0	235.6
4/8/15	161.9	327.5	310.1	303.7	286.3	321.5	304.1

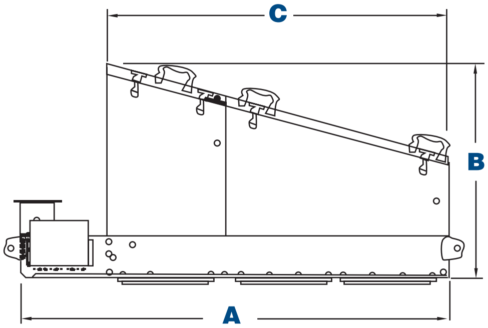
DLMC Operating Conditions	Standard	Optional
Seismic Spectral Acceleration	$S_S = 1.5$ & $S_1 = 0.6$	–
Wind Load Rating (mph)	90	–
Housing Rating ("wg)	0-20	21-45
Compressed Air Required (psig)	55-90	_
Temperature Range	15°F to 140°F	140°F to 400°F

Insertable Dimensions & Specifications



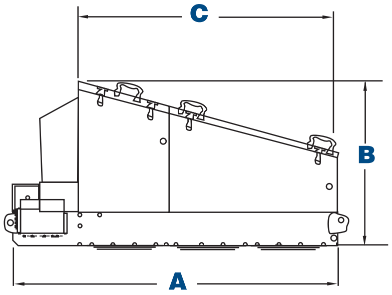
DLMV Type B

Basic filter for pressure systems located indoors.



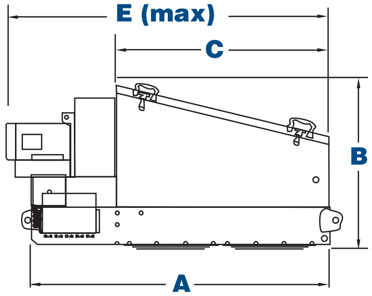
DLMV Type H

(Type B plus exit header)
Filter with exit header for connection to a fan or discharge ducting. The filter is weatherproof and suitable for indoor and outdoor application.



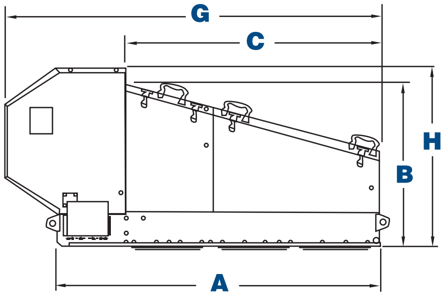
DLMV Type W

(Type H plus weather cowl)
Filter with a weather cowl for pressure systems where the filter is located outdoors or exposed to adverse conditions.



DLMV Type F

(Type H plus integral fan)
Weatherproof filter fitted with an integral fan for negative pressure applications.



DLMV Type FAD

(Type F plus acoustic diffuser)
Weatherproof filter fitted with an integral fan and acoustic diffuser for quiet operation.

DLMV Model	No. of Bags	Dimensions (inches)								
		A	B	C	D	E	F	G	H	J
4/7, 6/10, 9/15	6	38.3	36.8	33.8	27.5	43.1	29.1	57.4	43.3	14.7
7/7, 10/10, 15/15	10	38.3	36.8	33.8	43.3	43.1	39.8	57.4	43.3	14.7
8/7, 12/10, 18/15	12	62.2	36.8	44.5	27.6	64.0	29.1	71.6	43.3	15.7
14/7, 20/10	20	62.3	36.8	44.5	43.3	67.0	39.8	71.7	43.3	15.8
30/15	20	62.3	37.6	44.5	43.3	68.4	39.8	71.7	43.3	15.8
21/7, 30/10, 45/15	30	85.9	42.9	68.1	43.3	93.1	39.8	100.0	46.8	15.8
60/15	40	112.2	42.9	88.8	43.3	113.3	39.8	120.7	46.8	15.8

Insertable Dimensions & Specifications

DLMV Model	Nominal Airflow Range (cfm)*	Cloth Area (ft^2)	4:1 cfm	6:1 cfm	8:1 cfm	No. of Valves	Fan	Motor (hp)	Shipping Weight (lbs)				
									Type B	Type H	Type W	Type F	Type FAD
4/7	215 - 555	43	172	258	344	3	F1	1	231	320	331	430	523
6/10	320 - 830	64	256	384	512	3	F1	1	251	340	351	450	543
7/7	375 - 975	75	300	450	600	5	F1	1	353	474	485	584	688
							K3	2				595	699
8/7	430 - 1,115	86	344	516	688	6	F1	1	375	518	529	628	727
							K3	2				640	739
9/15	485 - 1,260	97	388	582	776	3	F1	1	273	362	373	472	565
							K3	2				483	576
10/10	540 - 1,400	108	432	648	864	5	F1	1	386	507	519	617	721
							K3	2				628	732
12/10	645 - 1,675	129	516	774	1032	6	K3	2	414	558	569	679	778
							K5	3				712	811
14/7	750 - 1,950	150	600	900	1200	5	K3	2	606	794	805	915	1025
							K5	3				948	1058
15/15	805 - 2,090	161	644	966	1288	5	K3	2	423	545	556	666	770
							K5	3				699	803
18/15	970 - 2,520	194	776	1164	1552	6	K3	2	459	602	613	723	822
							K5	3				756	855
							K7	5				833	932
20/10	1,075 - 2,795	215	860	1290	1720	5	K3	2	672	860	871	981	1091
							K5	3				1014	1124
							K7	5				1091	1201
21/7	1,130 - 2,935	226	904	1356	1808	10	K3	2	794	1058	1080	1179	1307
							K5	3				1213	1341
							K7	5				1290	1418
30/10	1,615 - 4,195	323	1292	1938	2584	10	K5	3	893	1157	1179	1312	1440
							K7	5				1389	1517
							K10	7.5				1561	1689
30/15	1,615 - 4,195	323	1292	1938	2584	10	K5	3	750	935	946	1089	1199
							K7	5				1168	1278
							K10	7.5				1321	1431
45/15	2,420 - 6,290	484	1936	2904	3872	10	K7	5	1003	1268	1290	1499	1627
							K10	7.5				1671	1799
							K11	10				1758	1886
60/15	3,230 - 8,395	646	2584	3876	5168	10	K11	10	1323	1878	1900	2374	2506

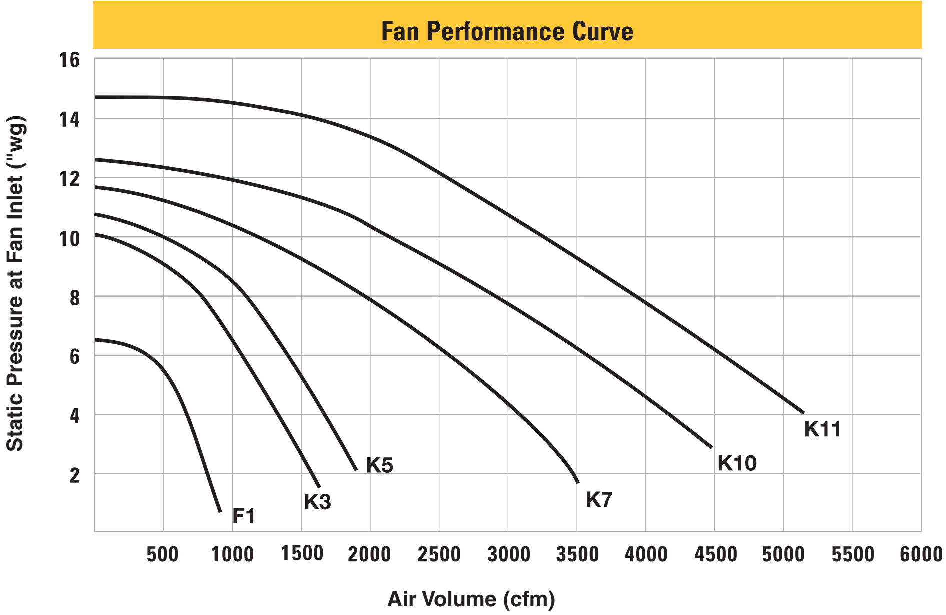
DLMV Operating Conditions	Standard	Optional
Pressure Limits	Type B, W and H: -16"wg	
	Type F: As fan performance curves from shut-off to ambient pressure	
Compressed Air Required (psig)	65-90	
Temperature Range	14°F to 140°F	140°F to 250°F (not Type F)

* Based on clean filters.

Insertable Performance Selections

To select the most suitable fan for your applications

1) Determine the air volume flow (cfm) needed to give effective venting and dust control
2) Estimate pressure or suction ("wg) in the housing in which the dust filter is inserted
3) Assess the operational pressure drop ("wg) across the clean side and dirty side of the filtering element – usually between 2 to 4 "wg
4) The sum of 2 and 3 gives the pressure ("wg) required for fan selection purposes
5) Consult graph for fan performance available



Insertable Weighted Sound Pressure Levels

All readings were taken in semi-reverberant surroundings 3'3" radius from the equipment housing and 5'3" above base level, using a precision sound level meter and octave filter.

	F1 (1 hp)	K3 (2 hp)	K5 (3 hp)	K7 (5 hp)	K10 (7.5 hp)	K11 (10 hp)
With acoustic diffuser*	76 dB(A)	73 dB(A)	74 dB(A)	76 dB(A)	79 dB(A)**	84 dB(A)
Without acoustic diffuser	91 dB(A)	89 dB(A)	92 dB(A)	93 dB(A)	94 dB(A)	97 dB(A)

Noise measurements of installed equipment may vary due to site conditions.
* These measurements refer to standard outlet position.
** Estimated data.

Dalamatic®

Standard Features & Equipment Options

Dalamatic Cased (DLMC)

	Standard	Optional
Collector Design		
Mild Steel Construction	✗	
Horizontal Clean-Side Bag Removal	✗	
Rear Dirty-Air Plenum Access Door		✗
High Temperature Construction		✗
Stainless Steel Construction		✗
Mountable Fan		✗
Ladders, Cages, & Platform Assemblies (OSHA compliant)		✗
Bags & Cages		
Dura-Life Twice the Life Polyester Felt Bags	✗	
Quick-Release Filter Clamps		✗
Variety of Bag Media Options		✗
Anti-Static Filter Bags		✗
Paint System		
Powder-Coated Polyester Textured Finish	✗	
Blue Exterior Finish Coating Meets 250-Hour Salt Spray Corrosion Protection Test	✗	
Hostile Environment Paint		✗
Custom Colors		✗
Hopper Design		
Pyramid Hoppers	✗	
Trough Hoppers	✗	
2 and 3 Bank Single-Outlet Hopper	✗	
UMA Hopper		✗
Support Structure		
Standard Leg Pack	✗	
Leg Extensions		✗
Electrical Controls, Gauges and Enclosures		
Solid-State Control Panels and Valves in NEMA 4 Encl.	✗	
Solid-State Control Panels and Valves in NEMA 9 Encl.		✗
Control Panels and Valves with Heater in NEMA 9 Encl.		✗
Magnehelic®* Gauge		✗
Solenoid Enclosure NEMA 9		✗
Photohelic®* Gauge		✗
Delta P Control, Delta P Plus Control		✗
Compressed Air Filter and Regulator		✗
Safety Features		
Sprinkler Pack		✗
Explosion Vents		✗
Warranty		
10-Year Warranty	✗	

Dalamatic Insertable (DLMV)

	Standard	Optional
Collector Design		
Mild Steel Construction	✗	
Horizontal or Vertical Bag Removal	✗	
High Temperature Construction		✗
Stainless Steel Construction		✗
Acoustic Diffuser Silencers		✗
Fans (AMCA "C" Rated) and Motors		✗
Bags & Cages		
Dura-Life Twice the Life Polyester Felt Bags	✗	
Clean-Side Bag Removal	✗	
Quick-Release Filter Clamps		✗
Variety of Bag Media Options		✗
Anti-Static Filter Bags		✗
Paint System		
Powder-Coated Polyester Texture	✗	
Blue Exterior Finish Coating Meets 250-Hour Salt Spray Corrosion Protection Test	✗	
Hostile Environment Paint		✗
Custom Colors		✗
Support Structure		
Vertical or Horizontal Upstands		✗
Electrical Controls, Gauges and Enclosures		
Solid-State Control Panels and Valves in NEMA 4 Encl.	✗	
Solid-State Control Panels and Valves in NEMA 9 Encl.		✗
Control Panels and Valves with Heater in NEMA 9 Encl.		✗
Magnehelic®* Gauge		✗
Solenoid Enclosure NEMA 9		✗
Photohelic®* Gauge		✗
Delta P Control, Delta P Plus Control		✗
Compressed Air Filter and Regulator		✗
Safety Features		
Explosion Proof Motors		✗
Warranty		
10-Year Warranty	✗	

* Magnehelic and Photohelic are registered trademarks of Dwyer Instruments, Inc.

U.S. Patent 7,015,158

Information contained in this document is subject to change without notice.

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Appendix B: Preliminary Calculations

Heating Design Load Estimation

Project: **Yukon College Biomass**
Date Prepared: 19-Aug-09
Prepared by: Sbirrell
location: Whitehorse
FSC Ref#: 2009-4350

2008-2009

ASSUMPTIONS:

1 E = CD*(86.4*Qls*DD)/(k*DT)
ref: ASHRAE Fundementals handbook, 1989, SI ver, pg F28.2
where:
E= fuel or energy consumption for estaimte period, kJ
CD = correction factor for heating effect vs. kelvin degree days
Qls = design heat loss incl. inflitration and ventilation, W
DD= Kelvin degree days, C
k = correction factor for heating system
DT = design temperature difference, C

2 Use degree day data for Whitehorse, Yk

3 fuel oil consumption = E/fuel oil heating value

4 Day loss and hours assume ventilation system off at night, therefore outdoor air off so night heat loss lower.

5 old heating system, assume inefficient.

6 fuel oil = # 2 diesel fuel oil

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada 2008-2009

16%	Jan DD	1142	July DD	128	2%
13%	Feb DD	955	Aug DD	178	2%
12%	Mar DD	869	Sep DD	322	4%
7%	Apr DD	532	Oct DD	563	8%
5%	May DD	354	Nov DD	783	11%
3%	Jun DD	193	Dec DD	1186	16%
			Total DD:	7204	100%

Correction factor CD:	0.8	
heat loss day		
heat loss night	0 W	
ave occupied hours	24 hrs	
ave unoccupied hours	0 hrs	
correction factor k:	0.5	
Delta Temp	62 C	
Fuel Oil heating Value, mJ/L	38.2 mJ/L	ref. ASHRAE 1989, F15.6, table 6
Equipment efficiency	80%	

OUTPUT: Monthly peak load W

Jan	1,251,151 W	July	
Feb	1,434,341 W	Aug	
Mar	1,410,118 W	Sep	
Apr		Oct	1,628,831 W
May		Nov	1,383,490 W
Jun		Dec	1,172,554 W

Peak load 1,629 kW

Heating Design Load Estimation

Project: **Yukon College Biomass**
Date Prepared: 19-Aug-09
Prepared by: Sbirrell
location: Whitehorse
FSC Ref#: 2009-4350

2007-2008

ASSUMPTIONS:

1 E = CD*(86.4*Qls*DD)/(k*DT)
ref: ASHRAE Fundementals handbook, 1989, SI ver, pg F28.2
where:
E= fuel or energy consumption for estaimte period, kJ
CD = correction factor for heating effect vs. kelvin degree days
Qls = design heat loss incl. inflitration and ventilation, W
DD= Kelvin degree days, C
k = correction factor for heating system
DT = design temperature difference, C

2 Use degree day data for Whitehorse, Yk

3 fuel oil consumption = E/fuel oil heating value

4 Day loss and hours assume ventilation system off at night, therefore outdoor air off so night heat loss lower.

5 old heating system, assume inefficient.

6 fuel oil = # 2 diesel fuel oil

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada 2007-08

17%	Jan DD	1114	July DD	102	2%
14%	Feb DD	955	Aug DD	154	2%
11%	Mar DD	735	Sep DD	308	5%
8%	Apr DD	512	Oct DD	544	8%
5%	May DD	322	Nov DD	725	11%
2%	Jun DD	141	Dec DD	1070	16%
			Total DD:	6680	100%

Correction factor CD:	0.8	
heat loss day		
heat loss night	0 W	
ave occupied hours	24 hrs	
ave unoccupied hours	0 hrs	
correction factor k:	0.5	
Delta Temp	62 C	
Fuel Oil heating Value, mJ/L	38.2 mJ/L	ref. ASHRAE 1989, F15.6, table 6
Equipment efficiency	80%	

OUTPUT: Monthly peak load W

Jan	1,088,562 W	July	
Feb	1,255,018 W	Aug	
Mar	1,498,043 W	Sep	
Apr		Oct	1,669,864 W
May		Nov	1,316,238 W
Jun		Dec	1,348,089 W

Peak load 1,670 kW

Heating Design Load Estimation

Project: **Yukon College Biomass**
Date Prepared: 19-Aug-09
Prepared by: Sbirrell
location: Whitehorse
FSC Ref#: 2009-4350

2006-2007

ASSUMPTIONS:

1 E = CD*(86.4*Qls*DD)/(k*DT)
ref: ASHRAE Fundementals handbook, 1989, SI ver, pg F28.2
where:
E= fuel or energy consumption for estaimte period, kJ
CD = correction factor for heating effect vs. kelvin degree days
Qls = design heat loss incl. infiltration and ventilation, W
DD= Kelvin degree days, C
k = correction factor for heating system
DT = design temperature difference, C

2 Use degree day data for Whitehorse, Yk

3 fuel oil consumption = E/fuel oil heating value

4 Day loss and hours assume ventilation system off at night, therefore outdoor air off so night heat loss lower.

5 old heating system, assume inefficient.

6 fuel oil = # 2 diesel fuel oil

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada 2006-07

13%	Jan DD	916	July DD	118	2%
14%	Feb DD	999	Aug DD	202	3%
14%	Mar DD	954	Sep DD	296	4%
7%	Apr DD	519	Oct DD	521	7%
5%	May DD	347	Nov DD	1162	17%
2%	Jun DD	173	Dec DD	824	12%
			Total DD:	7031	100%

Correction factor CD:	0.8	
heat loss day		
heat loss night	0 W	
ave occupied hours	24 hrs	
ave unoccupied hours	0 hrs	
correction factor k:	0.5	
Delta Temp	62 C	
Fuel Oil heating Value, mJ/L	38.2 mJ/L	ref. ASHRAE 1989, F15.6, table 6
Equipment efficiency	80%	

OUTPUT: Monthly peak load W

Jan	1,088,431 W	July	
Feb	1,026,227 W	Aug	
Mar	1,046,785 W	Sep	
Apr		Oct	1,163,721 W
May		Nov	1,102,735 W
Jun		Dec	1,155,365 W

Peak load 1,164 kW

Heating Design Load Estimation

Project: **Yukon College Biomass**
Date Prepared: 19-Aug-09
Prepared by: Sbirrell
location: Whitehorse
FSC Ref#: 2009-4350

2005-2006

ASSUMPTIONS:

1 E = CD*(86.4*Qls*DD)/(k*DT)
ref: ASHRAE Fundementals handbook, 1989, SI ver, pg F28.2
where:
E= fuel or energy consumption for estaimte period, kJ
CD = correction factor for heating effect vs. kelvin degree days
Qls = design heat loss incl. infiltration and ventilation, W
DD= Kelvin degree days, C
k = correction factor for heating system
DT = design temperature difference, C
2 Use degree day data for Whitehorse, Yk
3 fuel oil consumption = E/fuel oil heating value
4 Day loss and hours assume ventilation system off at night, therefore outdoor air off so night heat loss lower.
5 old heating system, assume inefficient.
6 fuel oil = # 2 diesel fuel oil

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada 2005-06

17%	Jan DD	1096	July DD	133	2%
13%	Feb DD	821	Aug DD	151	2%
14%	Mar DD	906	Sep DD	299	5%
7%	Apr DD	453	Oct DD	535	8%
4%	May DD	257	Nov DD	774	12%
2%	Jun DD	154	Dec DD	794	12%
			Total DD:	6373	100%

Correction factor CD:	0.8	
heat loss day		
heat loss night	0 W	
ave occupied hours	24 hrs	
ave unoccupied hours	0 hrs	
correction factor k:	0.5	
Delta Temp	62 C	
Fuel Oil heating Value, mJ/L	38.2 mJ/L	ref. ASHRAE 1989, F15.6, table 6
Equipment efficiency	80%	

OUTPUT: Monthly peak load W

Jan	1,117,706 W	July	
Feb	1,091,685 W	Aug	
Mar	1,269,277 W	Sep	
Apr		Oct	1,796,240 W
May		Nov	1,421,738 W
Jun		Dec	1,547,114 W

Peak load 1,796 kW

Appendix C: Reference Material

McCALL ENVIRONMENTAL

September 21, 2009

FSC Architects & Engineers
Suite 202 - 107 Main St.,
Whitehorse, YT
Y1A 2A7

Attention: **Sandy Birrell**
Re: **Air Emission Sampling Quotation/Protocols**

As requested our firm is providing you with some background information and some typical pricing on testing requirements at a proposed biomass heating system in Whitehorse, YT.

Testing Parameters- (Typical in BC)

- Total Particulate & Condensable Organics (Modified EPA Method 5/State of Oregon Method 7
- PM$_{10\text{-}2.5}$ particle sizing- Univ of Washington Cascade Impactor
- O_2-CO_2- EPA Method 3A instrumental (measured continuously via paramagnetic & NDIR)
- CO- EPA Method 10 instrumental (measured continuously via NDIR)

The above mentioned methodology would be typical for a new plant startup in British Columbia and for warranty purposes on the pollution abatement equipment.

After a satisfactory break-in period the above mentioned testing would be replicated for repeatability and then there would be a lesser annual requirement for air permitting purposes usually composing of only the particulate/particle sizing component.

Sampling methodology will be supplied with this quotation. Our company brochure is available for download from our website: www.mccallenvironmental.net

McCall Environmental
5111 Eagle Tree Pl
Victoria, B.C.
V9C 4H9
Tel: (250) 381-7482
Fax: (250) 381-7483
neil_mccall@telus.net

"Testing today for your children's tomorrow"

McCall Environmental
5100 Nightingale Rd.
Prince George, B.C.
V2K 5V9
Tel: (250) 962-6921
Fax: (250) 962-6931
mmccall@telus.net

Quotation

Total Particulate/Condensable Organics	$2750
Particle Sizing	$2500
Continuous Emission Monitoring (gasses)	$2000
Travel & Accommodation (from Prince George)	$3000
Lab Analysis/Report Generation	$1000

The above mentioned quotation is based on there being one stack and having two personnel on-site for one to two days. Delays beyond our control once onsite (plant breakdown) would have extra charges applied.

If you have any questions concerning this quotation or concerning the attached methodology please don’t hesitate to contact us at your earliest convenience.

Sincerely,

MCCALL ENVIRONMENTAL

Matt McCall

“Testing today for your children’s tomorrow”

Table 5.1
Summary of Regulatory Criteria for $PM_{2.5}$

Country	Province, State or Municipality	Current Criteria ($\mu g/m^3$)			Proposed Criteria ($\mu g/m^3$)				Implementation
		3 h	24 h	annual	1 h	4-8 h	24 h	annual	
Canada	Canada-Wide Standard		30						Final CWS was set at 30 $\mu g/m^3$, 98th percentile averaged over 3 consecutive years, spatially averaged over community-oriented area monitors; achievement by 2010
	Newfoundland		25						Standard adopted in 1996 based on 50% of PM_{10} objectives in BC and Ontario
	Alberta				80		30		Draft objectives proposed in 2005, to be used for permitting purposes
			20-30						Monitoring and non-mandatory management planning
			15-20						Monitoring only
	Manitoba		30						Objective used for permitting purposes
	Quebec	35	25						Used for air quality index
	Montreal	35	25						Used for air quality index
	Ontario	<23							3-h average denotes "Good" air quality in provincial air quality index; 24-h average used as benchmark value
	British Columbia								
	CRD		25						Monitoring and reporting guideline value
	GVRD	25	12						Adopted in 2005
	City of Quesnel		20						98th percentile averaged over 3 consecutive years; goal to be achieved by 2007
			18						98th percentile averaged over 3 consecutive years; goal to be achieved by 2010
	Whistler							~5-6	Implied $PM_{2.5}$ target level, based on a proposed PM_{10} target level of 10 $\mu g/m^3$
Australia			25	8					Advisory reporting standard only; community-oriented monitoring sites; review of standard to begin in 2005
New Zealand			25						Interim guideline; review of guideline to begin in 2005

Country	Province, State or Municipality	Current Criteria ($\mu g/m^3$)			Proposed Criteria ($\mu g/m^3$)				Implementation
		3 h	24 h	annual	1 h	4-8 h	24 h	annual	
World Health Organization			25	10					99th percentile for the 24-hour average guideline
			75, 50, 37.5	35, 25, 15					Suggested interim targets to be used to gauge progress towards the recommended guidelines
European Union	All member states							25	Averaged over all urban background monitoring sites in the EU Member state, over 3 consecutive years; achievement by 2010
United States	NAAQS		65	15			25-35	15	Primary NAAQS Option ‘A’: 98th percentile form of the standard if the 24-hour average standard is set at 25-30 $\mu g/m^3$, or the 99th percentile if the standard is set in the 30-35 $\mu g/m^3$ range; elimination of area averaging for proposed primary standards
							30-40	12-14	Primary NAAQS Option ‘B’: percentile form of the standard is not defined
						20-30			Daylight hours only (92-98th percentile) for secondary NAAQS
	California			12					24-h average proposed by Health Committee in 2002 but not adopted due to GAM statistical error
	Puget Sound Region		25	15					Proposed as goals by Health Committee in 1999 and adopted as goals by the Region, but 24-hour average value not adopted as standard; annual average value based on 1 year

Colour Key:

🟧	Legally-binding standards
🟨	Objectives or monitoring and reporting standards
🟩	Monitoring or reporting standards, guidelines, or targets

Note: The compilation of information on $PM_{2.5}$ criteria in other jurisdictions was completed in December 2005, and may not reflect subsequent changes, particularly with respect to the proposed revisions of the NAAQS in the United States.

http://epa.gov/air/criteria.html
Last updated on Tuesday, July 14th, 2009.

Air and Radiation

You are here: EPA Home Air and Radiation National Ambient Air Quality Standards (NAAQS)

National Ambient Air Quality Standards (NAAQS)

The Clean Air Act, which was last amended in 1990, requires EPA to set **National Ambient Air Quality Standards** (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. ***Primary standards*** set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. ***Secondary standards*** set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards (OAQPS) has set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants. They are listed below. Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air ($\mu g/m^3$).

National Ambient Air Quality Standards

	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm ($10\ mg/m^3$)	8-hour (1)	None	
	35 ppm ($40\ mg/m^3$)	1-hour (1)		
Lead	$0.15\ \mu g/m^3$ (2)	Rolling 3-Month Average	Same as Primary	
	$1.5\ \mu g/m^3$	Quarterly Average	Same as Primary	
Nitrogen Dioxide	0.053 ppm ($100\ \mu g/m^3$)	Annual (Arithmetic Mean)	Same as Primary	
Particulate Matter (PM_{10})	$150\ \mu g/m^3$	24-hour (3)	Same as Primary	
Particulate Matter ($PM_{2.5}$)	$15.0\ \mu g/m^3$	Annual (4) (Arithmetic Mean)	Same as Primary	
	$35\ \mu g/m^3$	24-hour (5)	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour (6)	Same as Primary	
	0.08 ppm (1997 std)	8-hour (7)	Same as Primary	
	0.12 ppm	1-hour (8)	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm ($1300\ \mu g/m^3$)	3-hour (1)
	0.14 ppm	24-hour (1)		

---

(1) Not to be exceeded more than once per year.

(2) Final rule signed October 15, 2008.

(3) Not to be exceeded more than once per year on average over 3 years.

(4) To attain this standard, the 3-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m3.

(5) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m3 (effective December 17, 2006).

(6) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm. (effective May 27, 2008)

(7) (a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.

(8) (a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is $\leq$ 1.
(b) As of June 15, 2005 EPA has revoked the 1-hour ozone standard in all areas except the fourteen 8-hour ozone nonattainment Early Action Compact (EAC) Areas. For one of the 14 EAC areas (Denver, CO), the 1-hour standard was revoked on November 20, 2008. For the other 13 EAC areas, the 1-hour standard was revoked on April 15, 2009.

Important legal notice
English (en)

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Air Quality Standards

Humans can be adversely affected by exposure to air pollutants in ambient air. In response, the European Union has developed an extensive body of legislation which establishes health based standards and objectives for a number of pollutants in air. These standards and objectives are summarised in the table below. These apply over differing periods of time because the observed health impacts associated with the various pollutants occur over different exposure times.

Pollutant	***Concentration***	***Averaging period***	***Legal nature***	***Permitted exceedences each year***
Fine articles (PM2.5)	25 µg/m3***	1 year	Target value enters into force 1.1.2010 Limit value enters into force 1.1.2015	n/a
Sulphur dioxide (SO2)	350 µg/m3	1 hour	Limit value enters into force 1.1.2005	24
	125 µg/m3	24 hours	Limit value enters into force 1.1.2005	3
Nitrogen dioxide (NO2)	200 µg/m3	1 hour	Limit value enters into force 1.1.2010	18
	40 µg/m3	1 year	Limit value enters into force 1.1.2010*	n/a
PM10	50 µg/m3	24 hours	Limit value enters into force 1.1.2005**	35
	40 µg/m3	1 year	Limit value enters into force 1.1.2005**	n/a

Lead (Pb)	0.5 µg/m3	1 year	Limit value enters into force 1.1.2005 (or 1.1.2010 in the immediate vicinity of specific, notified industrial sources; and a 1.0 µg/m3 limit value applies from 1.1.2005 to 31.12.2009)	n/a
Carbon monoxide (CO)	10 mg/m3	Maximum daily 8 hour mean	Limit value enters into force 1.1.2005	n/a
Benzene	5 µg/m3	1 year	Limit value enters into force 1.1.2010**	n/a
Ozone	120 µg/m3	Maximum daily 8 hour mean	Target value enters into force 1.1.2010	25 days averaged over 3 years
Arsenic (As)	6 ng/m3	1 year	Target value enters into force 1.1.2012	n/a
Cadmium (Cd)	5 ng/m3	1 year	Target value enters into force 1.1.2012	n/a
Nickel (Ni)	20 ng/m3	1 year	Target value enters into force 1.1.2012	n/a
Polycyclic Aromatic Hydrocarbons	1 ng/m3 (expressed as concentration of Benzo(a)pyrene)	1 year	Target value enters into force 1.1.2012	n/a

**Under the new Directive the member State can apply for an extension of up to five years (i.e. maximum up to 2015) in a specific zone. Request is subject to assessment by the Commission. . In such cases within the time extension period the limit value applies at the level of the limit value + maximum margin of tolerance (* 48 µg/m3 for annual NO2 limit value).

***Under the new Directive the Member State can apply for an extension until three years after the date of entry into force of the new Directive (i.e. May 20011) in a specific zone. Request is subject to assessment by the Commission. In such cases within the time extension period the limit value applies at the level of the limit value + maximum margin of tolerance (35 days at 75*µg/m3 for daily PM10 limit value, 48 µg/m3 for annual Pm10 limit value).

****Standard introduced by the new Directive.*

Under EU law a limit value is legally binding from the date it enters into force subject to any exceedances permitted by the legislation. A target value is to be attained as far as possible by the attainment date and so is less strict than a limit value.

The new Directive is introducing additional PM2.5 objectives targetting the **exposure** of the population to fine particles. These objectives are set at the national level and are based on the average exposure indicator (AEI).

AEI is determined as a 3-year running annual mean PM2.5 concentration averaged over the selected monitoring stations in agglomerations and larger urban areas, set in urban background locations to best assess the PM2.5 exposure to the general population.

Title	***Metric***	***Averaging period***	***Legal nature***	***Permitted exceedences each year***
PM2.5 Exposure concentration obligation	20 µg/m3 (AEI)	Based on 3 year average	Legally binding in 2015 (years 2013,2014,2015)	n/a
PM2.5 Exposure reduction target	Percentage reduction* + all measures to reach 18 µg/m3 (AEI)	Based on 3 year average	Reduction to be attained where possible in 2020, determined on the basis of the value of exposure indicator in 2010	n/a

** Depending on the value of AEI in 2010, a percentage reduction requirement (0,10,15, or 20%) is set in the Directive. If AEI in 2010 is assessed to be over 22 µg/m3, all appropriate measures need to be taken to achieve 18 µg/m3 by 2020.*

Principles

European legislation on air quality is built on certain principles. The first of these is that the Member States divide their territory into a number of zones and agglomerations. In these zones and agglomerations, the Member States should undertake assessments of air pollution levels using measurements and modelling and other empirical techniques. Where levels are elevated, the Member States should prepare an air quality plan or programme to ensure compliance with the limit value before the date when the limit value formally enters into force. In addition, information on air quality should be disseminated to the public. See more under Implementation.

Last updated: 30/04/2008 E-mail this page Top

Air Quality Standards

Air quality is measured by comparing against a range of health-effects based standards. This page gives information about what this means.

- Standards
- Air Pollution Information Service
- Index or Banding

Air Quality Standards and Objectives

Standards for air pollution are concentrations over a given time period that are considered to be acceptable in the light of what is scientifically known about the effects of each pollutant on health and on the environment. They can also be used as a benchmark to see if air pollution is getting better or worse.

An exceedence of a standard is a period of time (which is defined in each standard) where the concentration is higher than that set down by the standard. In order to make useful comparisons between pollutants, for which the standards may be expressed in terms of different averaging times, the number of days on which an exceedence has been recorded is often reported.

An objective is the target date on which exceedences of a standard must not exceed a specified number.

The objectives adopted in the UK are defined in the latest Air Quality Strategy for England, Scotland, Wales and Northern Ireland, published on 17th July 2007. Those which are limit values required by EU Daughter Directives on Air Quality have been transposed into UK law through the Air Quality Standards Regulations 2007 which came into force on 15th February 2007.

A summary of the current UK Air Quality Objectives is provided here.

UK Air Quality Objectives for protection of human health, July 2007 - New objectives highlighted in shading

Pollutant	Air Quality Objective		To be achieved by
	Concentration	Measured as	
Benzene All authorities	16.25 µg m^{-3}	Running annual mean	31 December 2003
England and Wales Only	5.00 µg m^{-3}	Annual mean	31 December 2010
Scotland and N. Ireland	3.25 µg m^{-3}	Running annual mean	31 December 2010
1,3-Butadiene	2.25 µg m^{-3}	Running annual mean	31 December 2003
Carbon Monoxide England, Wales and N. Ireland	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31 December 2003
Scotland Only	10.0 mg m^{-3}	Running 8-hour mean	31 December 2003
Lead	0.5 µg m^{-3}	Annual mean	31 December 2004
	0.25 µg m^{-3}	Annual mean	31 December 2008
Nitrogen Dioxide	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	31 December 2005
	40 µg m^{-3}	Annual mean	31 December

			2005
Particles (PM10) (gravimetric)			
All authorities	50 µg m^{-3}, not to be exceeded more than 35 times a year	Daily mean	31 December 2004
	40 µg m^{-3}	Annual mean	31 December 2004
Scotland Only	50 µg m^{-3}, not to be exceeded more than 7 times a year	Daily mean	31 December 2010
	18 µg m^{-3}	Annual mean	31 December 2010
Particles (PM2.5) (gravimetric) *	25 µg m^{-3} (target)	Annual mean	2020
All authorities	15% cut in urban background exposure	Annual mean	2010 - 2020
Scotland Only	12 µg m^{-3} (limit)	Annual mean	2010
Sulphur dioxide	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	31 December 2004
	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean	31 December 2004
	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean	31 December 2005
PAH *	0.25 ng m^{-3}	Annual mean	31 December 2010
Ozone *	100 µg m^{-3} not to be exceeded more than 10 times a year	8 hourly running or hourly mean*	31 December 2005

*** not included in regulations at present**
Shaded data shows new objectives

UK Air Quality Objectives for protection of vegetation and ecosystems, July 2007 - New objectives highlighted in shading

Pollutant	**Air Quality Objective**		**To be achieved by**
	Concentration	**Measured as**	
Nitrogen dioxide (for protection of vegetation & ecosystems) *	30 µg m^{-3}	Annual mean	31 December 2000
Sulphur dioxide (for protection of vegetation & ecosystems) *	20 µg m^{-3} 20 µg m^{-3}	Annual mean Winter Average (Oct - Mar)	31 December 2000
Ozone *	18000 µg m^{-3}.h	AOT40^{+}, calculated from 1h values May-July. Mean of 5 years, starting 2010	01 January 2010

*** not included in regulations at present**
$^{+}$ AOT 40 is the sum of the differences between hourly concentrations greater han 80 µg m^{-3} (=40ppb) and 80 µg m^{-3}, over a given period using only the 1-hour averages measured between 0800 and 2000.
Shaded data shows new objectives

Air Pollution Information Service

Index and Bands

In the UK most air pollution information services use the index and banding system approved by the **Committee on Medical Effects of Air Pollution Episodes** (COMEAP). The system uses 1-10 index divided into four bands to provide more detail about air pollution levels in a simple way, similar to the sun index or pollen index.

1-3 (Low)
4-6 (Moderate)
7-9 (High)
10 (Very High)

The overall air pollution index for a site or region is calculated from the highest concentration of five pollutants:

Nitrogen Dioxide
Sulphur Dioxide
Ozone
Carbon Monoxide
Particles < 10µm (PM10)

Air Pollution Forecasts

Air Quality Forecasts are issued on a regional basis for three different area types:

In towns and cities near busy roads
Elsewhere in towns and cities
In rural areas

Forecasts are based on the prediction of air pollution index for the **worst-case** of the five pollutants listed above, for each region.

Health Advice

Latest studies report that:

When air pollution is LOW (1-3) effects are unlikely to be noticed even by those who are sensitive to air pollution.
When air pollution is MODERATE (4-6) sensitive people may notice mild effects but these are unlikely to need action.
When air pollution is HIGH (7-9) sensitive people may notice significant effects and may need to take action.
When air pollution is VERY HIGH (10) effects on sensitive people, described for HIGH pollution, may worsen.

Air pollution can cause short-term health effects to sensitive individuals (people who suffer from heart disease or lung diseases, including asthma). Effects on sensitive people can be reduced by spending less time outdoors. 'Reliever' inhalers should lessen effects on asthma sufferers.

More details on effects, including long-term, are available in a free leaflet **'Air Pollution - what it means for your health'.**

Air Pollution Bandings and Index and the Impact on the health of People who are Sensitive to Air Pollution

Banding	Index	Health Descriptor
Low	**1, 2, or 3**	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants
Moderate	**4, 5, or 6**	Mild effects, unlikely to require action, may be noticed amongst sensitive individuals.
High	**7, 8, or 9**	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung.
Very High	**10**	The effects on sensitive individuals described for 'High' levels of pollution may worsen.

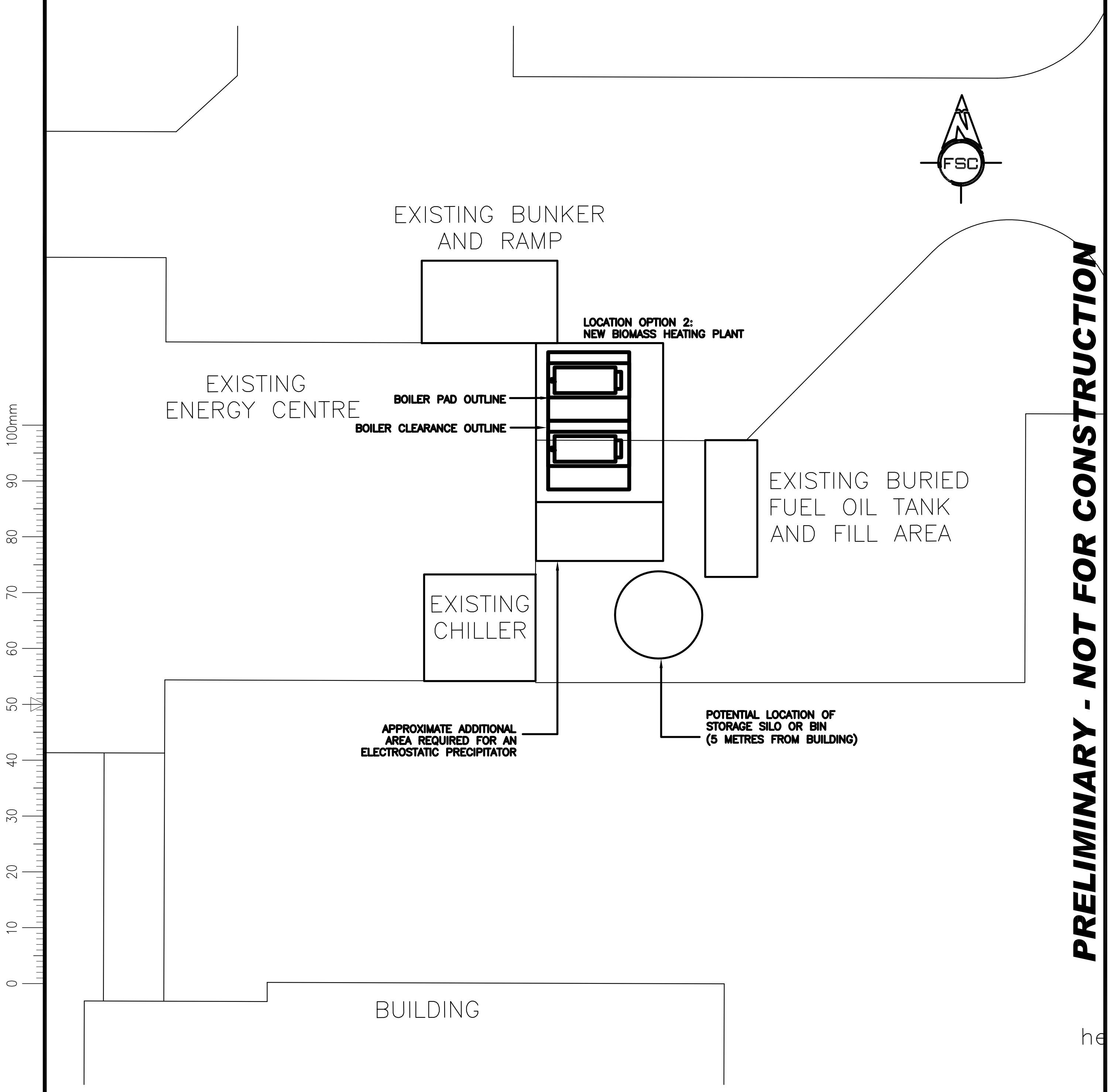
Boundaries Between Index Points for Each Pollutant

Band	**Index**	**Ozone**		**Nitrogen Dioxide**		**Sulphur Dioxide**		**Carbon Monoxide**		**PM10 Particles**	
		Running 8 hourly or hourly mean*		**hourly mean**		**15 minute mean**		**Running 8 hourly mean**		**Running 24 hour mean**	
		μgm^{-3}	ppb	μgm^{-3}	ppb	μgm^{-3}	ppb	mgm^{-3}	ppm	μgm^{-3} (Grav. Equiv.)	μgm^{-3} (Ref. Equiv.)
Low											
	1	**0-33**	**0-16**	**0-95**	**0-49**	**0-88**	**0-32**	**0-3.8**	**0.0-3.2**	**0-21**	**0-19**
	2	34-65	17-32	96-190	50-99	89-176	33-66	3.9-7.6	3.3-6.6	22-42	20-40
	3	66-99	33-49	191-286	100-149	177-265	67-99	7.7-11.5	6.7-9.9	43-64	41-62
Moderate											
	4	100-125	50-62	287-381	150-199	266-354	100-132	11.6-13.4	10.0-11.5	65-74	63-72
	5	126-153	63-76	382-477	200-249	355-442	133-166	13.5-15.4	11.6-13.2	75-86	73-84
	6	154-179	77-89	478-572	250-299	443-531	167-199	15.5-17.3	13.3-14.9	87-96	85-94
High											
	7	180-239	90-119	573-635	300-332	532-708	200-266	17.4-19.2	15.0-16.5	97-107	95-105
	8	240-299	120-149	636-700	333-366	709-886	267-332	19.3-21.2	16.6-18.2	108-118	106-116
	9	300-359	150-179	701-763	367-399	887-1063	333-399	21.3-23.1	18.3-19.9	119-129	117-127
Very High											
	10	360 or more	180 or more	764 or more	400 or more	1064 or more	400 or more	23.2 or more	20 or more	130 or more	128 or more

* For ozone, the maximum of the 8 hourly and hourly mean is used to calculate the index value.

This website is prepared and hosted by AEA, on behalf of the UK Department for Environment, Food & Rural Affairs and the Devolved Administrations

Appendix D: Sketches



1 M1 NEW BIOMASS BOILER PLANT LOCATED IN NEW BUILDING NTS

PROJECT TITLE
YUKON COLLEGE BIOMASS BOILERS

CLIENT PROJECT NO.
-

FSC PROJECT NO.
2009-4350

FSC
ARCHITECTS & ENGINEERS

Suite 202, 107 Main Street
Whitehorse, YT, Y1A 2A7, Canada
Tel: (867) 633-2400 Fax: 633-2481

LOCATION
WHITEHORSE, YT.

DRAWING TITLE
BIOMASS HEATING PLANT
LOCATED IN NEW BUILDING
ISSUED FOR CONCEPT DESIGN

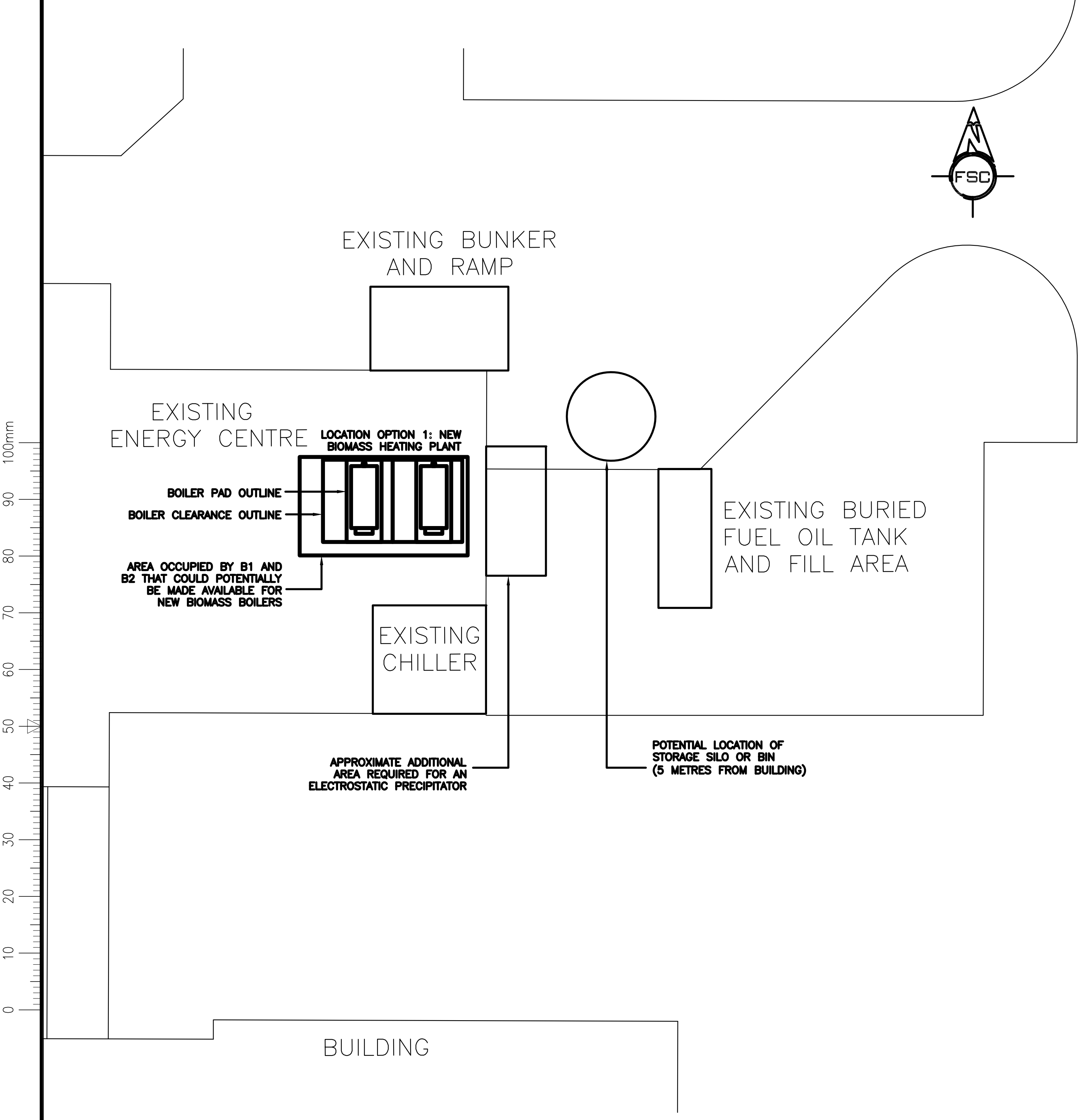
DRAWN BY
SB

CHECKED BY
LF

SCALE
NTS

DATE
2009/09/18

DRAWING NO.
M1 OF 1



PRELIMINARY - NOT FOR CONSTRUCTION

1
M1
NEW BIOMASS BOILER PLANT LOCATED WITHIN ENERGY CENTRE
NTS

PROJECT TITLE **YUKON COLLEGE BIOMASS BOILERS**	CLIENT PROJECT NO. -	FSC PROJECT NO. 2009-4350
LOCATION WHITEHORSE, YT.	DRAWN BY SB	CHECKED BY LF
DRAWING TITLE BIOMASS HEATING PLANT LOCATED WITHIN ENERGY CENTRE ISSUED FOR CONCEPT DESIGN	SCALE NTS	DATE 2009/09/18
	DRAWING NO. M2	OF 1

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