INTRODUCTION BROCHURE

SYSTEM JOHANSSON GASPRODUCER

Manufactured and Supplied

by

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EXECUTIVE SUMMARY

- The “System Johansson Gasproducer”, when operated according to the Operation and Maintenance Manual, produces tar free gas suitable as fuel for internal combustion engines.

- Five standard types are available with a capacity range of 120 to 850 Nm3/hr to power electric generators from 50 to 400 KVA. Larger Types with higher outputs can be designed on demand.

- Average Production Ratio is 1,2 kg wood = 1 KVA, depending on the type of fuel and its moisture content.

- The SJG can operate 24 hours / day continuously without being stopped for refuelling and deashing.

- Operating lifespan is estimated at plus 20 years.

- Operating is done by skilled Tractor Diesel Mechanics, which will be properly trained.

- Maintenance Work and cost are minimal.

- Besides Hard- and Soft Wood a number of Agricultural waste can be used as fuel by hard compacting into briquettes.

- Operation is safe when carried out in accordance with the comprehensive manual.

- For larger plants semi and full automatic options are available on specific demand.

- Process effluents, like condensate can be recycled at low cost and the scrubber / cooler water can be used for a long period of time and is non toxic.

- With hot gas- and combustion air fans, applying a special design Woodgas Burner the SJG can used as heat source for driers, boilers and small turbines.

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THE ENVIRONMENTALLY FRIENDLY WOOD GAS PRODUCER SYSTEM WITH TAR FREE CONTINOUS GAS PRODUCTION FOR ELECTRIC POWER AND HEAT APPLICATIONS

1. GAS PRODUCER DESCRIPTION

The System Johansson Gas Producer has been developed as an environmentally friendly downdraft wood gasification technology on the principle that all tar is cracked at high temperature with long gas residence time in the pre-heated refractory cast-cement hearth. It has been designed for varying load on demand, as is necessary for continuous char surplus. The gas when leaving the gas producer is **tar-free**.

This is a fully developed, reliable and clean, over many years long-term tested source of renewable biomass energy for direct engine/generator or heat applications. It has been specially designed for use in developing countries, where communities have the will and government support to establish their own energy plantations in suitable areas with straight and fast growing clean trees while at the same time creating new employment and learning opportunities. If the plantations were large, they would contribute to reduce the green house effect with assimilation of the CO_2 in the air through photosynthesis by the oxygen producing trees.

The whole integral Gas Producer System has also been designed for simplicity and safety, provided that the Operator's and Safety Instructions are followed. Small plants can under Developing World conditions be operated by persons with only an experienced tractor driver's skills, while larger plants will need to be operated under the guidance of an engineer or a qualified mechanic. Large capacity fuel compartments are provided to allow for extended time between re-fuelling, which is important when used as electricity power supply during late night time, low power output hours with isolated communities.

The gas producers are also suitable for use with forest- or sawmill waste converted to fuel of specified piece shape and size. High density briquetted sawdust, groundnut husks, sunflower shells and other Biomass materials have been successfully tested without producing any tar. In warm sunny climates the logs, after being cut to suitable handling lengths, are normally stacked to dry for a few months before being converted into wood block fuel or coarse chunks. The sun drying is usually enough, but after-drying with engine radiator waste heat may sometimes be necessary.

For fuel drying in cold or rainy climates as well as with wet sawmill waste, exhaust gas fuel dryers can be used. Since no tar is produced, the clean gas producer system can, for use in Industrialised Countries, be adapted with semi or full automated function control and suitable modifications for mechanisation to the refuelling and ash removal systems.

The Fuel Compartment with its shape and volume in relation to the maximum gas production forms an integral part of the **tar free gas producer system**. To avoid fuel hang-up the drying and carbonisation funnel have been determined to allow for free through-flow without obstruction. The average shrinkage of wood during drying and the necessary controlled speed of carbonisation at high temperature in relation to volume reduction and char demand has also been taken into account with the hearth design.

The whole gas producer system operates under vacuum. This makes the system safe against gas poisoning, particularly during re-fuelling with continuous non-stop working as long as the engine or in the case of heating applications, the gas suction fan is running. The pre-heated primary air makes the system respond instantaneously to any variations in the gas demand.

The tar free gas producer design is based on tar cracking formulas. The wood gas producer system is available in 5 different Standard Design Normal Sizes, from 120 Nm^3/h to 850 Nm^3/h gas production, (50 KVA to 400 KVA) or (180 Kw_{th}/h to 1,300 kW_{th}/h for heat application) respectively. There are also 5 Special Design Large Non-Standard Sizes from 1,100 Nm^3/h to 2,400 Nm^3/h gas production, but at this stage only design data is available.

The gas producers are provided with primary air nozzles, giving the correct pre-heated air velocity to allow for full air penetration through the coarse char in the combustion zone, even at low power. The primary air is pre-heated through a built-in heat exchanger, which conserves heat and increases the hearth temperature.

SJG Gas Producers have been long-term tested with trouble free performance under actual working conditions over many years.

2. TAR FREE WOOD GAS REFERENCE

The reference to **"tar free"** wood gas generation is based on the fact that no tar could be detected in the clean gas during the early CSIR tests with the original prototype carried out during 1984 and 1985. Later tests conducted by CRE with a 450 Nm^3/h SJGas Producer in the UK during 1993-1995 also found no tar in the gas. From long-term continuous combined tar and dust tests carried out over many years, when the gas producers have powered generators with varying electric power output, the average total combined tar plus 5 micron dust collected on the safety filter has been about 6 mg/Nm^3 clean gas.

3. WOOD GAS ANALYSIS

During 1983 and 1984 CSIR carried out various internal temperature measurements, gas analysis and gas producer performance tests with the first tar free S J G proto-type gas producer. The average gas composition from the gas analysis when converted to air free gas is as shown below. The effective heat values varied slightly, mainly as a result of variations in the wood fuel moisture content.

AVERAGE SJG WOOD GAS ANALYSIS BY CSIR

CO_2%	CO%	H_2%	CH_4%	N_2% RESIDUAL
10,7 - 9,8	22,2 -24,3	22,3 - 22,5	1,90 - 2.10	42,9 - 41,5

The average effective heat value of the air free gas varied between 5,900 kJ/Nm^3 to 6,250 kJ/Nm^3 while the volume of gas formed under low power conditions was 2,2 Nm^3/kg wood block fuel. At full power the wood consumption increased due to duffing and carbon losses, while the volume of gas formed per kg wood decreased to about 2 Nm^3/kg wood. The early CSIR practical working gas yield results were confirmed many years later during tests carried out with the larger, for continuous working designed, System Johansson Wood Gas Producer delivered to Eskom (Electricity Supply Commission of South Africa).

CRE also carried out gas analysis in the UK during 1995 on gas from a 450 Nm^3/h System Johansson Gas Producer, when high density sawdust briquettes were used as fuel. These UK test results showed a higher gas heat value than what was recorded by CSIR with the first tests, when Eucalyptus Camaldulensis wood block fuel was used. No tar was detected with any of these tests.

4. BASIC OPERATION

The gas producers are supplied with properly matching 220 volt single phase 50 Hz electric starter fans. On sites where 220 volt electric power supply is not available, a 12 volt or 24 volt battery powered DC electric fan can be used for starting.

Where a dual wood gas/diesel generator is running on wood gas, the starter fan as well as the cooling water pump can be powered from the generator. It is started and runs on 100% diesel during the short time required for the starting of the gas producer. When the gas is ready and after the generator has been switched on, delivering power, it is only then switched over to dual wood gas/diesel operation.

The igniting of a gas producer is done through the hearth igniter sleeve, while the raw gas flare-off valve is open and the starter fan running, by inserting a few sparklers locked in a sparkler holder. In an emergency, starting can also be done by inserting a small glowing wooden stick.

As there is no tar in the gas, the cooling and cleaning is a simple operation, which does not produce any dirty tar contaminated toxic water or deposits. Since it is not tar contaminated, the filter media lasts for a long period of time between the changes. The filter media is changed with one filter at a time without power interruptions. The lids are easily handled from a light overhead travelling rail chain tackle. Both the raw gas and the cooled and filtered clean gas is ignited and flared-off within 5- to 10 minutes from starting, with 220/10,000 volts electric ignition. On sites where 220 volts power is not available, the gas flare-off ignition can either be done with power from a battery powered DC / 220 volt AC inverter, or manually with a long handle-paraffin soaked torch, which is used with small gas producers.

Standard design normal size wood gas producers are, when working under Developing World conditions, easiest and quickest refuelled when using the simple affordable SJG electric micro-winch re-fuelling goose-neck with a “side-swing-gate” bottom opening fuel bucket, operated from the re-fuelling platform. Micro winches are available in suitable sizes. Large gas producers can use a re-fuelling skip or a slat- or bucket re-fuelling wood conveyor, in combination with a receiving hopper having an air-tight single sliding gate valve underneath on the gas producer top with an unsealed sliding gate valve against the wood fuel above as protection. Both are synchronised and operated by hydraulic or compressed air rams.

Standard size gas producers are provided with a single refuelling lid / explosion pressure release vent which helps to restrict the gas producer height, since when the gas producer is operated correctly, any smoke or gas emission from the lid when opened is sucked back into the gas producer because of the systems vacuum with the engine or suction gas fan running. The duration of refuelling is very short (3 to max.5 min.).

5. EXPLOSION PRESSURE RELEASE SAFETY VENTS

The Gas Producer, the Gas Scrubber/Cooler and the Filters have low pressure flat-spring loaded explosion release safety vents, which are released at a fraction of the allowable structural design pressure. These were tested satisfactorily by CSIR.

6. AUTOMATIC VARIABLE SPEED ASH GRATE ACTIVATOR

The Gas Producers are fitted with an electric, variable speed ash grate activator and with ash removal and refuelling systems for non-interrupted, continuous working. They are also supplied with 12-or 24 volt DC electronic fuel level indicators and with a red flashing early refuelling warning light which can, depending on the local noise control regulations, be combined with a sound alarm.

An electronic DC flashing red light ash removal warning system is provided for continuous non-interrupted working, with an ash-box having a normal minimum 5 hour storage capacity when using hard wood fuel. The soot and ash removal can also be modified for automatic continuous removal below the safety air-lock valve, which must not be removed, by using a slat conveyor submerged in a water filled portable steel trough, or by using a double air-lock auger conveyor.

When the ash grate speed is correctly adjusted the total loss of ash and carbon duffing, when using Eucalyptus Camaldulensis or Eucalyptus Sideroxylon wood, has been below 3,9% by weight of the wood fuel while the ash is also prevented from diluting the reduction char coal. This allows for safe continuous operation while the raw-gas temperature is lowered through the charcoal reduction inside the inverted reduction cone, to the acceptable gas temperature allowed for in the design.

The ash grate activator drive motor is protected against the excessive temperature.

7. CYCLONE

The raw-gas is passed through a cyclone, which removes the coarse dust from the raw-gas. From long-term recorded dust content tests of the raw-gas before and after the cyclone, it is estimated that on full power the 425 degrees C hot raw-gas may, with eucalyptus hard wood fuel contain some 5g dust particles per Nm^3 gas while with high density sawdust briquettes or pine / cypress wood fuel, the dust content is about 10g or even more per Nm^3 raw-gas.

When using fast growing eucalyptus wood fuel and operating at full power, the cyclone removes about 80% of the dust and soot, or say about $4g/Nm^3$, leaving the remaining about 20% fine dust and soot particles, or say $1g/Nm^3$ ($5 ml/Nm^3$) carried through to the gas scrubber/cooler. When the power output is reduced a “fixed” cyclone starts to lose efficiency. In order to overcome this, the cyclone of the SJG is fitted with a spring loaded gas vacuum / velocity regulator.

NB. When cypress or pine wood is used as gas producer fuel, all of the very fine light carbon silica dust can not be effectively removed by the cyclone. The remaining fine dust is then washed out and carried away with the scrubbing water to the cooling pond.

8. FUEL COMPARTMENT WITH CONDENSATES TRAP

The only tar containing effluent from the whole gas producer system is the wood fuel condensates formed in the fuel compartment, when the free water in the wood fuel is driven off during drying and carbonisation and condensed against the outside single wall of the fuel compartment.

With the SJG method the resulting fuel compartment condensates are drained off and prevented from running down into the hearth and wetting the char, so starting is always easily done on dry fuel. The condensates are produced in the small average quantities of between 0,025 litre to 0,05 litre per kg air-dry eucalyptus wood block fuel.

Since the quantity of condensates produced depends on the moisture content of the wood and during the rainy season also to a small degree on the moisture content in the primary air, variations from these limits may occur. When high density sawdust briquettes or very dry eucalyptus wood is used, no condensate is produced.

The tar content of the fuel compartment condensates has also been determined by the environmental water analysts "ERGOSAF", who have reported only about 2,5 g tar per litre condensates, when eucalyptus hard wood fuel was used. ESKOM tests of the condensates for phenols have established that the condensates contained between 12,5 mg to 14,7 mg phenols per litre. However, since the small volumes of condensates produced do contain phenols, this liquid must not be let out directly over the ground even if the phenols only represent less than 1 part phenols in 60,000 parts condensates.

The Inventor has also developed simple methods for the easy, affordable and safe recycling of the condensates. This is described in detail in his paper titled "WOOD GAS PRODUCER FUEL COMPARTMENT CONDENSATES".

Since the quantities of the wood fuel compartment condensates produced are small, the solid residues are easiest and safest finally destroyed in the hearth, after the odourless water evaporation has first taken place. The water is either evaporated in sun evaporators used in warm climates, or in exhaust gas or raw-gas hot evaporators used in cold or rainy climates.

9. GAS SCRUBBER / COOLER

After the coarse eucalyptus hard wood dust has been removed in the cyclone, about 1g/Nm^3 (5ml/Nm^3) fine dust is carried with the scrubbing water to the scrubber/cooler. In a subtropical climate during summer time the gas is cooled to between 20 to 25 degrees C and during mid winter time to between 10 to 15 degrees C .

The water is sprayed over a suitable low resistance hard, but porous, large surface area scrubbing media normally consisting of coarse, even graded hard wood charcoal, while the water is recycled through an ambient cooling pond for a long period of time. The circulating water pump is dimensioned for the correct flow and with suitable delivery pressure. It is provided with a low resistance over-dimensioned suction inlet filter and with clearly visible one or two pressure gauges, situated at the gas scrubber / cooler.

10. AMBIENT COOLING WATER POND

The simplest and most reliable and affordable cooling method to use in tropical, sub-tropical or moderately temperate climates, is either a natural earth pond or otherwise to use an inexpensive "Hydrex" wire-mesh heavy duty plastic lined irrigation pond. For continuous working in a sub-tropical climate, the tank should have a capacity of 400 litres cooling water per Nm^3/h gas cooled. In cold winter climates the water can also be pumped from the non-freezing +4 degrees C water layer between the top ice and the bottom of a dam, river or lake. In order to prevent freezing, the cooling water pipes must be buried in the ground and in the water to frost free depth.

In a tropical or sub-tropical climate it is, because of the absence of toxic compounds in the cooling water, necessary to chlorinate the water in order to prevent the growth of algae and mosquito larvae. *An ordinary cheap "inhibited chlorine" floating swimming pool chlorine tablet basket should be used. Ordinary un-inhibited chlorine must never be used since this could cause severe damage.* If the plant is running continuously, chlorinating is not necessary.

As an alternative cooling method, the cooling could be done by using a space saving SJG vacuum water fan cooler having its own vacuum water balancing tank, with provision for removing most of the dust and in cold climates also any water condensates, before these enter the reduced cooling water stream.

The gas scrubbing/cooling water, if let directly through the scrubber on a one use only basis, would contain less than 30 parts of solids per million of mainly lampblack carbon and fine silica particles with some traces of iron, manganese, zinc and lime.

The scrubbing water, both after being recycled for 18 months and also from "one-use-only" water, has been tested by the environmental water analysts "ERGOSAF" in order to determine the toxicity and any traces of tar, as well as the solids content. It was found that there are no traces of tar and that the water is non-toxic. The suspended solids are also low, as the sludge continuously sinks to the bottom of the cooling pond. The re-cycled scrubbing water can, according to the "ERGOSAF" test report, be let out over the ground without causing any harm to the environment.

11. LONG LIFE PARTICLE INTERFERENCE SAWDUST FILTERS

After the gas cooler/scrubber, the cooled gas is passed through the long life filters which are filled with coarse sawdust filter media which has been sieved from the coarse waste sawdust resulting from the wood block fuel cutting operation to maximum particle interference. The remaining, very light and fine non-wetable lampblack carbon dust of about 0,2g or 1 ml/Nm^3 gas is absorbed in the filter media. The filter media should be sieved on a System Johansson long amplitude vibrating sawdust screen combination, which produces the ideal particle interference filter media very quickly.

12. ENGINE SAFETY FILTERS

Before reaching the engine, the clean gas is finally passed through a standard 5 micron double cartridge Donaldson air filter or equivalent other type, modified as a safety gas filter with much reduced gas flow capacity. The safety filter types and sizes are specified in the Operator's Instructions. The engine safety filter does not form part of the gas cleaning system and it is only provided as a protection for the engine.

13. VACUUM INDICATOR PANELS

A calibrated multi-reading Vacuum Indicator Panel is supplied with each gas producer system. This has the advantage over separate vacuum gauges, since all the readings can be observed simultaneously from a distance.

Since the gas producer hearth vacuum influences all the other vacuums and the whole functioning of the gas producer system, it is necessary to particularly keep this vacuum within the allowable limits specified in the Operator's Instructions, which is easily done with the aid of the adjustable ash grate activator. The tensioning spring for the cyclone vacuum must also be adjusted so that the cyclone vacuum does not become too high.

During normal operation with the correct ash grate activator speed there is no build-up in the hearth vacuum, the only normal variations being caused by the change in the engine power output.

The system vacuums with the normal allowable limits shown in the Operator's Instructions, when the engine or gas suction fan is running, refer to the following:

1. The stopped starter fan, (this must be stopped before the engine is started).
2. The gas producer hearth.
3. The cyclone.
4. The gas scrubber/cooler.
5. The no.1 and no.2 main filters respectively.
6. The 5 micron engine gas safety filter.
7. The engine inlet manifold.
8. Provision can also be made for indicator readings in the event of a second dual wood gas/diesel engine being powered from the same gas producer.
9. If with wood gas burner applications a variable speed suction, low pressure delivery gas fan is used, the suction vacuum as well as the delivery gas pressure must then also be indicated.

The Vacuum Indicator Panel is normally situated next to and attached to the gas scrubber and must be clearly visible from a distance by the plant operator.

14. GAS PRODUCER FUEL

The whole integral gas producer system has been designed to be completely self contained, even on remote sites where clean suitable dry wood blocks or coarse chips of correct shape and size, or high density sawdust or agricultural harvest waste briquette fuel can be produced economically, or be supplied at a competitive affordable price from a reliable nearby outside source.

Small pulp wood chips can not be used for tar free gas generation, since the small restricted voids between the pulp chip "particles" prevent sufficient primary air penetration. Wood fuel made from most species of both hard and soft wood with the bark left on, including most of the many economically very important alien wood species growing in Africa and other countries, work well as long as the fuel is dry and of the correct piece shapes and sizes and free of slag forming impurities as specified in the Operator's Instructions. Dry coarse chips and high density sawdust- and ground nut husk briquettes have also worked well as fuel.

Analysis carried out on char produced from high density grass briquettes indicate that these would also work well as fuel. The maximum moisture content for biomass fuel should, however, not exceed 20% by weight when expressed on wet basis, but it is more economical to use dryer wood fuel. The "critical self flow-through volume weight" of the fuel must not be less than 200 kg/m^3 or briquettes with a density of at least 1,200 kg/m^3 solid mass and of the correct size and piece shapes should be used for reliable safe, continuous self-flow-through. With most wood species this poses no problem.

If it is planned to use any fuel which has not been tested with the gas producer system, it would be advisable to carry out tests. These tests should include determination of the loose volume weight of the fuel, the ash content, the carbon yield and char softness/hardness properties and if possible also the ash cintering temperature and the CAB (critical air blast) value for the char as well as the char reaction time and reaction temperature.

Reprocessed fuel containing plastics can not be used, since the chlorine produced at the high hearth temperature would very quickly destroy the hearth. Also fuel containing sulphur must not be used.

If old waste wood fuel should contain formaldehyde or melamine glues, ammonia would then be produced and contaminate the gas while damaging the aluminium alloy parts of an engine and also causing air pollution.

15. GENERATOR ENGINE CONVERSIONS

The gas producer system can supply gas fuel for three types of engines:

1.) Diesel engines converted to Dual Fuel (Diesel/Woodgas) operation.

2.) Gasoline (Petrol) engines converted to Woodgas operation.

3.) Gas engines converted to Woodgas operation.

Except Diesel engines all other engines must be spark ignited natural aspirated.

Conversion Technology can be provided.

Turbo aspirated diesel engines run well and almost reach “prime power” when converted to dual wood gas/diesel power. With regard to Turbo Aspiration, for Gas engines we are participating in developments in Germany and Japan, in design and tests of a low delivery pressure gas booster fan with sensitive delivery pressure control system to be fitted between the safety gas filter and the engine. We expect to be able to present this solution in the near future.

While engines converted to wood gas power complete with regulating valves would normally be purchased directly from an approved engine generator builder by a gas producer customer, the engine calculations and the matching with correct size gas producer will be provided with the gas producer systems supply. Existing diesel generators can easily be converted at affordable costs to dual wood gas/diesel power.

16. OPERATING FLEXIBILITY AND EFFICIENCY

The System Johansson Gas Producers work with a high gas producer output reduction of 6:1, as has been established with long term testing. With spark ignition the latter is based on zero power for turndown with the main switch off for short limited periods of time, in order not to damage the engine without any load. Then the full maximum power has been switched on instantaneously without the engine causing any drops in the revs.

The overall electrical power efficiency is dependent of the engine and alternator efficiencies, while the hot gas producer efficiency alone is about 80%, with cooled filtered gas efficiency being nearer 74%.

17. FUNCTION CONTROL

The combined effect from the removal of the excess fuel condensates, the primary air pre-heating and the on demand continuous char surplus as well as the automatic ash grate activation and high temperature of the refractory cast cement hearth, ensures that all tar is cracked at the long gas residence time. Also there is no variation in the gas heat value from when the fuel compartment is 100% full to when 75% of the fuel load has been burnt down. Although ash removal and refuelling can take place at any time while the engine is running, the 75% burned down fuel load limit when the flashing red fuel level warning light comes on, is the lowest safe fuel level allowed before refuelling.

The electronic fuel level indicators and refuelling warning system help to keep the operators informed about the fuel reserve. Through the red flashing warning light, which can be combined with a sound alarm, the operators are also reminded in good time when to re-fuel.

The large capacity ash collector box is provided with an electronic ash level sensor, activating a flashing red warning light system, in order to warn the operator if the ash and duffing carbon should rise too high. It is however advisable to remove the ash and soot at more frequent intervals, which like re-fuelling is done without interruption to the power output.

18. LIFESPAN AND MAINTENANCE

The gas producer design life is at least 20 years for all major fixed gas producer components, when the outside hearth containment as well as the fuel compartment are made from 3CR12 steel, but probably much longer provided that it is operated in accordance with the Operator's Instructions. However, seals and gaskets to lids have to be changed occasionally, while the electric gas igniters and the condensates screen need to be cleaned as and when required.

The internal bottom of the condensates collector pocket must also be cleaned when saturated. This can be done without stopping the engine. Re-painting should be done where and when required. The particle interference sieved sawdust filter media needs to be changed regularly, at intervals based on allowable specified vacuum readings, while the safety filter cartridge combination must be changed at recommended intervals.

The System Johansson Gas Producers will also function well in a tropical maritime environment as well as in cold winter climates. In the latter case, it will be necessary to insulate the filters with high heat insulation, light weight water proof covers. In very cold climates these can also be provided with electric blanket heating underneath the outside insulation, or with heating from the systems waste heat.

The Johansson Wood Gasification System provides a safe working environment for Operators and the Vicinity, as long as the Operator's and Safety Instructions are followed. Provisions have also been made to eliminate any foreseeable risks. The instructions and recommendations in the K G Johansson paper titled "Producer Gas Poisoning And Emergency Treatment", which will be issued to all buyers of gas producers, must be read and followed on all gas producer sites.

19. WOOD GAS PRODUCER PRICE ENQUIRIES AND PROJECT STUDIES ARE OBTAINABLE FROM:

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TABLE I. DETAILED DATA OF SYSTEM JOHANSSON *STANDARD DESIGN, NORMAL SIZE* WOOD GAS PRODUCERS FOR ENGINE AND HEATING APPLICATIONS.

The maximum gas production and power output given in the table below, is based on working at an atmospheric pressure of 760 mm Hg and a temperature of 0° C, as "normal" conditions. The power output is also based on using diesel engines converted to natural aspirated spark ignited wood gas power with reduced compression ratio and with valve timing modified for the slow wood gas combustion. A lower wood gas heat value of 5,500 kJ/Nm^3 with combined engine x alternator efficiencies as shown in the table below and including adjustment for unavoidable losses, has been used. Should the combined efficiencies vary from those given in this table, the power output can then be adjusted pro-rata.

Unavoidable efficiency losses occur with the combustion of wood gas in an internal combustion engine. These result mainly from volume reduction, as compared to expansion with the combustion of liquid petroleum fuel. There are also smaller losses resulting from the slight increase in the polytrophic exponent for the engine compression stroke and the small loss caused by the advanced timing, which is necessary for obtaining full wood gas combustion. In order to compensate for some of these losses an estimated 10% power reduction has been allowed, after converting the thermal energy to electric power, while using the combined engine x generator efficiencies as shown below.

GASPRODUCER STANDARD TYPE.	UNIT/ DATA	13-15 /30	16-30/60	20-60/100	25-100/150	35-150/300
MAX. GAS OUTPUT	Nm^3/h	120	180	300	450	850
MAX. THERMAL OUTPUT	kW_{th}	180	275	460	685	1,300
MAX.WOOD BLOCK FUEL CONSUMPTION	kg/h	60	90	150	225	425
GROSS VOLUME FULL FUEL COMPARTMENT	m^3	0,7	1,0	1,7	2,5	4,75
GROSS WEIGHT FULL SOFT WOOD (250 KG/M^3)	kg	175	250	425	625	1,180
GROSS WEIGHT FULL HARD WOOD (340 KG/M^3)	kg	240	340	580	850	1,600
COMBINED ENGINE x GENERATOR EFFICIENCY	%.	32	32	33	33	34
MAX. POWER OUT PUT WITH ABOVE COMBINED EFFICIENCY LESS 10%.	kVA	50	80	140	200	400
75% SAFE RUNNING TIME ON SOFT WOOD	Hrs	2,2	2,0	2,1	2,1	2,1
75% SAFE RUNNING TIME ON HARD WOOD	Hrs	3,0	2,8	2,8	2,8	2,8
MAIN SAWDUST FILTER DIAMETER (TWO OFF)	Metres	1,35	1,6	2,0	2,5	3,5
DONALDSON ENGINE SAFETY FILTERS	TYPE	FHG 08-0200 (1 OFF)	FHG 12-0014 (1 OFF)	FHG 14-0022 (1 OFF)	FHG 16-0048 (1 OFF)	FHG 16-0048 (2 OFF)

TABLE II. DETAILED DATA OF SYSTEM JOHANSSON *SPECIAL DESIGN, LARGE NON-STANDARD SIZE* WOOD GAS PRODUCERS FOR ENGINE AND HEATING APPLICATIONS.

SPECIAL DESIGN LARGE GAS PRODUCER TYPE	UNIT/ DATA		40-SPNS	45-SPNS	50-SPNS	55-SPNS	60-SPNS
MAX GAS OUTPUT		Nm^3/h	1,100	1,400	1,700	1,950	2,500
MAX. THERMAL OUTPUT	kW_{th}		1,680	2,140	2,675	2,980	3,820
MAX. WOOD BLOCK FUEL CONSUMPTION	kg/h		550	700	875	975	1,250
GROSS VOLUME FULL COMPARTMENT	m^3		6,1	7,7	9,4	10,8	13,9
GROSS WEIGHT FULL SOFT WOOD (250 KG/M^3)	kg		1,500	1,900	2,350	2,700	3,500
GROSS WEIGHT FULL HARD WOOD (340 KG/M^3)	kg		2,100	2,600	3,200	3,650	4,700
COMBINED ENGINE X GENERATOR EFFICIENCY	%		34	34	34	34	35
MAX. POWER OUTPUT WITH ABOVE COMBINED EFFICIENCY LESS 10%	kVA		500	650	800	900	1,200
75% SAFE RUNNING TIME ON SOFT WOOD	hrs.		2,1	2,1	2,1	2,1	2,1
75% SAFE RUNNING TIME ON HARD WOOD	hrs.		2,8	2,8	2,8	2,8	2,8
MAIN FILTER DIAMETER	metres		3,5 (3 OFF)	3,5 (4 OFF)	3,5 (4 OFF)	3,5 (5 OFF)	3,5 (6 0FF)
DONALDSON ENGINE SAF-ETY FILTERS WITH MANIFOLD	TYPE		FHG16-0048 (3 OFF)	FHG16-0048 (4 OFF)	FHG16-0043 (4 OFF)	FHG16-0043 (5 OFF)	FHG16-0043 (6 OFF)

THE SAWDUST FILTER DIAMETERS AS SHOWN, ARE RECOMMENDED FOR NORMAL WORKING CONDITIONS IN DEVELOPING COUNTRIES. GAS PRODUCERS CAN ALSO, IN ORDER TO PROLONG THE TIME BETWEEN PARTICLE INTERFERENCE SIEVED FILTER MEDIA CHANGES, BE SUPPLIED WITH MORE OR LARGER FILTERS ON REQUEST.

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