Application Database

GARDNER DENVER

Centrifugal Products Group

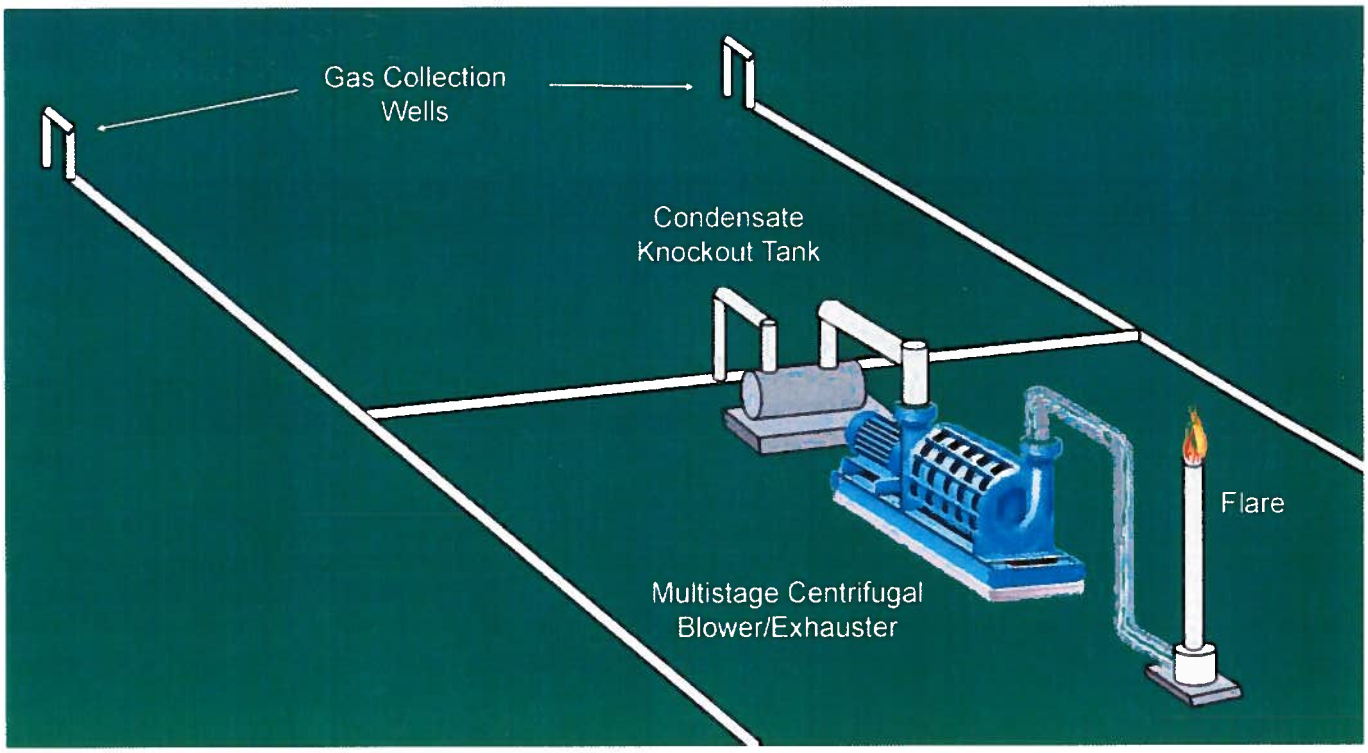
Industry: Waste Industry - Landfill

Application: Landfill Gas Extraction – Process Overview

Process: The organic waste in landfills is purposely covered and compressed by heavy equipment creating an anerobic condition that begins to decompose the organic matter. Perforated piping is used to control and draw off the resulting gas. Comprised of 50-70% methane (CH_4) and 25-50% carbon dioxide (CO_2), this gas is both hazardous and potentially useful. If allowed to build up, explosions can occur. If leached to the atmosphere, it contributes to smog as a volatile organic compound (VOC).

Since the Clean Air Act and Title 40 of the Code of Federal Regulations, in the United States, landfills must estimate the quantity of non-methane organic compounds emitted. If they exceed 50 tons per year, the landfill is required to contain and clean the gas to remove the non-methane organic compounds. Usually, the methane gas is then burned off or flared. If economically feasible, the gas is cleaned to pipeline quality "renewable natural gas" or "biomethane". The gas can be added to the gas pipeline grid and mixed with natural gas, or it can be used to heat water or air or heat part of an industrial process. If compressed, biomethane can power internal combustion or fuel cell vehicles.

If we are flaring the methane gas, we plot a vacuum curve and call the multistage centrifugal an "exhauster". If we are saving the gas for storage, heating or a process application, we will plot a pressure curve. In this application, we refer to the multistage centrifugal as a "blower".



Landfill Gas Extraction Process

Application Database

GARDNER DENVER

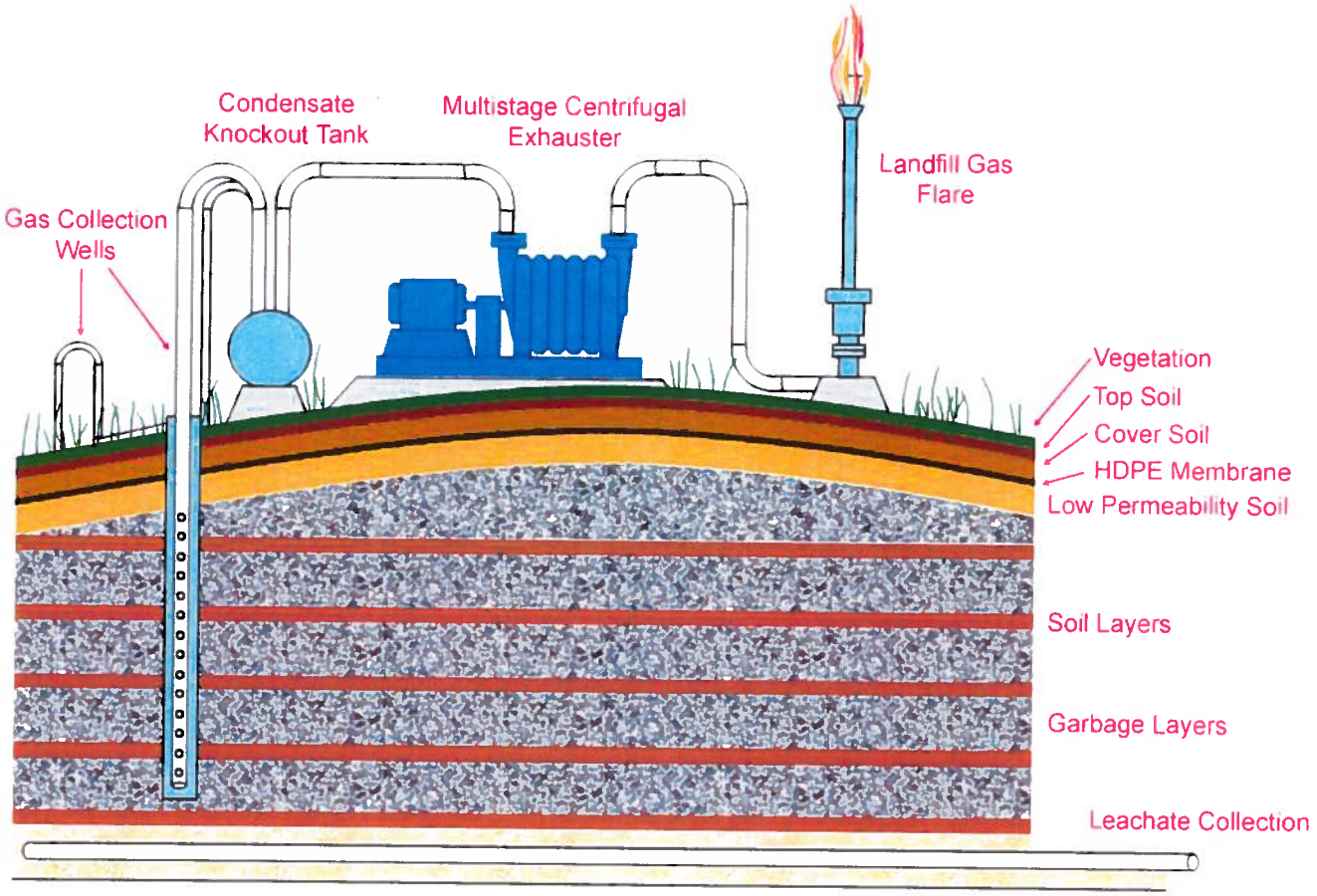
Centrifugal Products Group

Industry: Waste Industry - Landfill

Application: Landfill Gas Extraction to Flare

Process: The methane gas created by the anerobic process in a waste landfill must be vented to prevent explosions. This gas is usually flared off to be safely disposed of.

Areas are carefully prepared for new landfills with a base of clay, sand and membrane designed to prevent leachate from reaching the groundwater. A layer of garbage is added, compacted mechanically and topped with a layer of soil. Another layer of garbage and more soil is added, and so on until the landfill section is deemed full. The area is then topped with special low permeability soil, a HDPE membrane, more soil and a vegetation cover. Holes are bored and piping collects the potentially hazardous methane gas. The quantity of vent pipes is determined based on many factors including rate of decomposition, climate, thickness and quantity of layers, etc. A multistage centrifugal exhauster encourages the gas mixture, mostly methane gas and carbon dioxide to leave the landfill and sends it to the landfill gas vent flare.



Landfill Gas to Flare

Description: This process can use one or multiple multistage centrifugal exhausters. A single exhauster could draw from twenty or fifty vent pipes; however the vent pipes must be engineered to draw an even vacuum. Multiple exhausters can make this less of a problem.

Application Database

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- Gas Composition:

Methane gas	CH_4	50-70%
Carbon Dioxide	CO_2	25-50%
Nitrogen	N_2	0-10%
Hydrogen	H_2	0-1%
Hydrogen sulfide	H_2S	0-3%
Oxygen	O_2	0-2%

- Operating Conditions: The airflow varies considerably, but the vacuum required is usually 100-200 "H_2O (7.4-14.8 "Hg).
- Sizing Criteria: CF Select will determine the most efficient or cost effective exhauster for each situation.

Competitors:

Manufacturer	Technology	Models
HSI	Multistage Centrifugal	
Continental	Multistage Centrifugal	
Spencer	Multistage Centrifugal	
Roots	Positive Displacement	

Gardner Denver Products: Various series of multistage centrifugal exhausters are typical offerings. Smaller series multistage centrifugals will use packing ring seals, whereas larger exhausters will require carbon ring seals to prevent methane leakage. Carbon ring seals require purging, so a compressor will need to be nearby. Since these exhausters are often in very remote locations, this can be a problem. The impellers are Heresite coated and non-sparking coupling guards are used. Since condensate can build-up, a section drain pipe assembly is recommended for convenience.

Gardner Denver regenerative exhausters can be used in some landfill gas applications with appropriate airflow and vacuum ranges, but it would require a variable frequency drive (VFD) since TurboTrons cannot be throttled back like a multistage centrifugal.

- Marketing Position: Landfills are probably not as familiar with Gardner Denver, Lamson or Hoffman as some other market segments, but we have considerable experience and success with the application.
- Differentiation Strategy: In-house Heresite coatings should make a difference in delivery and quality control. This is a serious application from a standpoint of safety, reliability and durability and is better left to the company with the most experience.
- Advantages: Machines vary in size to meet the criteria required by the landfill engineers. Only Gardner Denver has the breadth of line to meet those needs most efficiently.
- Disadvantages: XXXXXXXXXXXXXXXXX

Key Users:

Larger landfills.

More Information:

Contact Marketing Services for the following:

- Sales brochure *Multistage Centrifugal Blowers / Exhausters* (GDCF-1-300)

Application Database

GARDNER DENVER

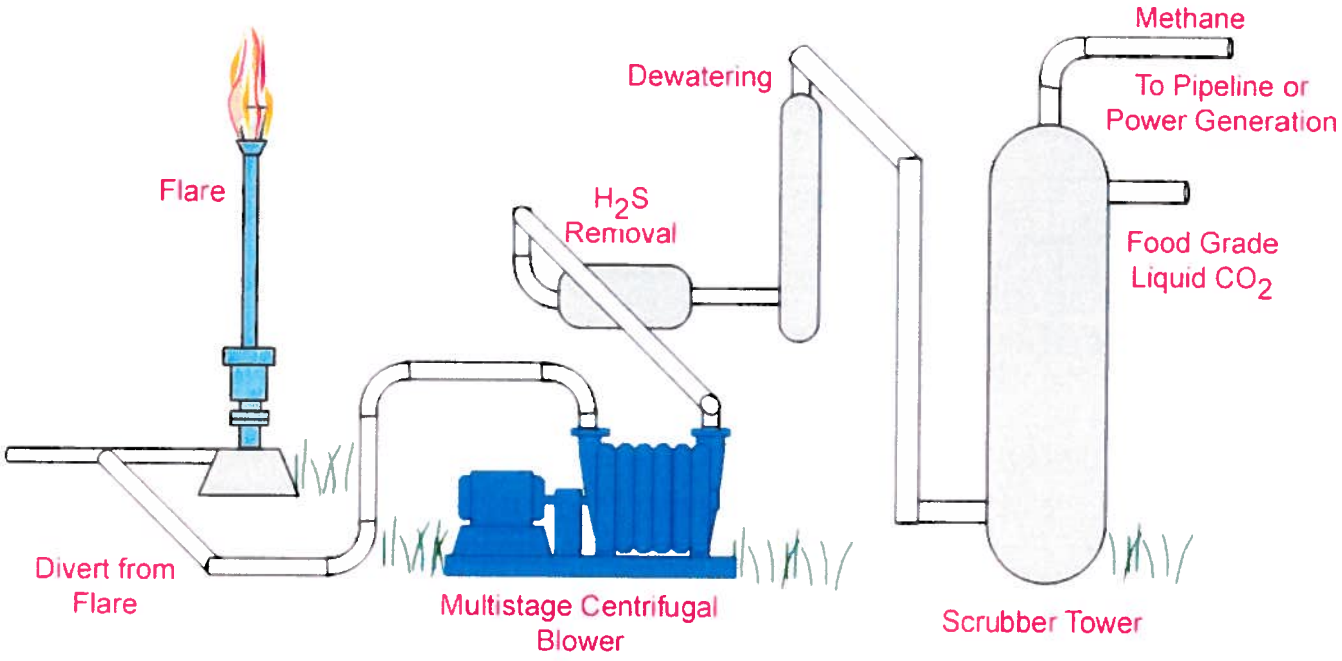
Centrifugal Products Group

Industry: Waste Industry - Landfill

Application: Landfill Gas Extraction to Save

Process: The methane gas created by the anerobic process in a waste landfill must be vented to prevent explosions. This gas can be valuable and is often saved.

If economically feasible, the gas is cleaned to pipeline quality "renewable natural gas" or "biomethane". The gas can be added to the gas pipeline grid and mixed with natural gas, or it can be used to heat water or air or heat part of an industrial process. If compressed, biomethane can power internal combustion or fuel cell vehicles.



Landfill Gas to Save

Description: Typically, after the landfill gas exhauster passes the methane and carbon dioxide mixture, it is diverted to a second blower which goes to hydrogen sulfide removal, a dryer and scrubber tower or to clean the gas. At this time, food grade CO2 can be separated from the methane. Siloxane trace contaminants are also removed, which hinder combustion. An aftercooler may be required to cool the volatile methane gas after compression. The cleaned methane gas moves to a storage vessel where it can be used in process or added to the natural gas grid.

- Gas Composition:

Methane gas	CH_4	50-70%
Carbon Dioxide	CO_2	25-50%
Nitrogen	N_2	0-10%
Hydrogen	H_2	0-1%
Hydrogen sulfide	H_2S	0-3%
Oxygen	O_2	0-2%

Application Database

GARDNER DENVER

Centrifugal Products Group

- Operating Conditions: The airflow varies, but the pressure required is usually 3-4 psig.
- Sizing Criteria: CF Select will determine the most efficient or cost effective exhauster for each situation.

Competitors:

Manufacturer	Technology	Models
HSI	Multistage Centrifugal	
Continental	Multistage Centrifugal	
Spencer	Multistage Centrifugal	
Roots	Positive Displacement	

Gardner Denver Products: 550 or 850 series multistage centrifugal blowers are typical offerings. Smaller series multistage centrifugals will use packing ring seals, whereas larger exhausters will require carbon ring seals to prevent methane leakage. Carbon ring seals require purging, so a compressor will need to be nearby. Since these blowers are often in very remote locations, this can be a problem. The impellers are Heresite coated and non-sparking coupling guards are used. Since condensate can build-up, a section drain pipe assembly is recommended for convenience.

- Marketing Position: Landfills are probably not as familiar with Gardner Denver, Lamson or Hoffman as some other market segments, but we have considerable experience and success with the application.
- Differentiation Strategy: In-house Heresite coatings should make a difference in delivery and quality control. This is a serious application from a standpoint of safety, reliability and durability and is better left to the company with the most experience.
- Advantages: Machines vary in size to meet the criteria required by the landfill engineers. Only Gardner Denver has the breadth of line to meet those needs most efficiently.
- Disadvantages: XXXXXXXXXXXXXXXX

Key Users:

Larger landfills.

More Information:

Contact Marketing Services for the following:

- Sales brochure *Multistage Centrifugal Blowers / Exhausters* (GDCF-1-300)

APPLICATION CODE: 34

APPLICATION TYPE: Gas recovery - Landfills

MAJOR CUSTOMERS: LFG Specialties, John Zinc Company

TYPICAL GAS MIXTURE: 50% CH_4, 50% CO_2

TYPICAL BLOWER FRAMES: Exhausters 310-1270

KEY FEATURES: Flammable, corrosive

MAIN COMPONENT GROUPS:

1. *Shaft:* CS
Steel

2. *Bearing housing:*
Closed

3. *Lubrication:*
Grease or oil

4. *Seal:*
Packing box, purged labyrinth or purged double carbon ring seal

5. *Inlet/outlet heads:*
Gray cast iron, Bisonite coated, drains

6. *Sections:*
Gray cast iron, Bisonite coated, internal / external drains

7. *Impeller:*
Aluminum, 355 T6, Bisonite coated

8. *Baffle ring:*
Brass. electroless Nickel plated

9. *Balance piston /cylinder:*
Ductile iron, bisonite coated / Steel & lead

MOST COMMON OPTIONS:

Subject to specifications, galvanized base plates (against corrosion)

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SPECIFICATION 1:

SO# 68270 LFG Specialties (1997)
Blower type: 403, 4350 RPM, belt driven
Gas mixture: 50% CH_4, 50% CO_2

Inlet / Outlet temperature: 100 F / F
Inlet / Outlet pressure: -38"H_2O / +15" H_2O

Non standard Lamson specifications:

Toshiba 213T TEFC motor, 50 Hz, 7.5 HP
Drains on outlet head and sections
Packing gland, labyrinth
Bisonite coating to inlet/outlet heads, sections, impellers
Internal drains

SPECIFICATION 2:

SO# 68532 John Zinc Company (1998)
Salt River Landfill
Blower type: 515, 3525 RPM, belt driven
Gas mixture: 50% CH_4, 50% CO_2

Inlet / Outlet temperature: 130 F / 182 F
Inlet / Outlet pressure: -60" H_2O / +20" H_2O

Non standard Lamson specifications:

Reliance frame 284TS TEFC motor, 60 Hz, 25 HP
Packing gland, labyrinth
Drains on outlet head and sections 3/8" SST nipples and 3/8" ball valve
Base and motor pedestal hot dip galvanized X OFFER EPOXY COATED (3 WK LT OUTSOURCE) ?
Aluminum coupling gard
Rexnord flexible element coupling, E4
Heads, sections and impellers bisonite coated.
(external coating of drains?)

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**********************************************************
*    SMARTPIK II - AUTO BLOWER MECHANICAL SELECTION      *
**********************************************************

GENERAL:
 DATE =                 5/21/98          ENGINEER =          Helene B

BLOWER:
 BLOWER FRAME:          1270
 Outlet Pres, psig =    10.0             # of STAGES =       8
 Inlet Position =       2                Outlet Temp, F =    250
 Bearing Model =        6315             Outlet Position =   3

MAJOR DIMENSIONS, inches:
 Inlet Flange =         14.0             Outlet Flange =     12.0
 Shaft Dia =            5.50             Stg Spacing =        6.50
 B DIMENSION =          65.25            A DIMENSION =       58.50
 BLOWER HEIGHT =        64.13            BLOWER WIDTH =      47.00

WEIGHTS, MOMENT OF INERTIA & CRITICAL SPEED:
 BLOWER WT, lb =          7620           ROTOR WT,lb =       735
 ROTOR WK2, lb-ft^2 =                    164.4
 CRITICAL SPEED, rpm =                   4160

PRICES:
 BLOWER (standard material) =                        US$   15961.0
 Non-Standard material =                             US$    4784.0
 Options =                                           US$    5772.0
 TOTAL BLOWER PRICE =                                US$   39775.5

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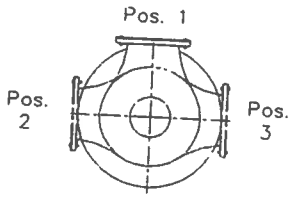
APPLICATION:
 APPLICATION CODE:    34
 CATEGORY:            Exhausting & Venting
 APPLICATION:         Landfill
 DESCRIPTION:         Methane & CO2, flammable & corrosive

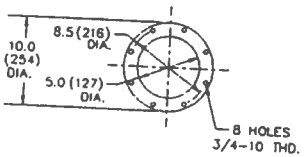
BLOWER CONSTRUCTION (MATERIALS & OPTIONS):
 SHAFT:               AISI-4140 STEEL
 BEARING HOUSING:     OPEN STYLE, CAST IRON
                        - WITH VIBRATION PROBE
                        - WITH TEMPERATURE PROBE
                        - WITH INPRO SEAL
 LUBRICATION:         OIL LUBRICATION
 SHAFT SEAL:          DOUBLE CARBON RING
                        - WITH PRESSURE PURGE
 INLET/OUTLET HEADS:  GREY CAST IRON (ASTM A48 GRADE 25/30)
                        - WITH BISONITE COATING
 SECTION:             GREY CAST IRON (ASTM A48 GRADE 25/30)
                        - WITH BISONITE COATING
 IMPELLER:            CAST AL 355-T6
                        - WITH BISONITE COATING
 BAFFLE RINGS:        MONEL ALLOY
 BALANCE PISTON:      DUCTILE IRON & STEEL
                        - WITH BISONITE COATING
```

NO.	CHANGE DESCRIPTION	ECN/ECO	DRAWN/DATE	CHK'D	APP'D
0	RELEASE				

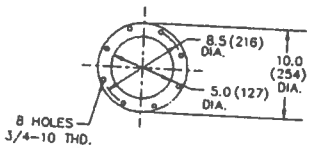


Inlet Positions

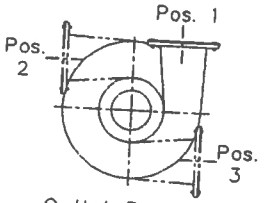
VIEWED FROM INLET



INLET

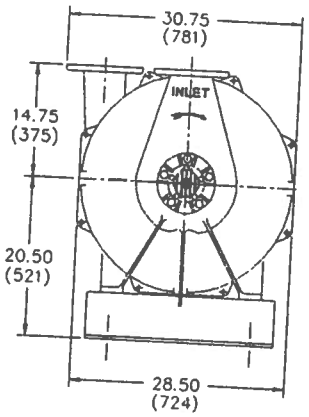


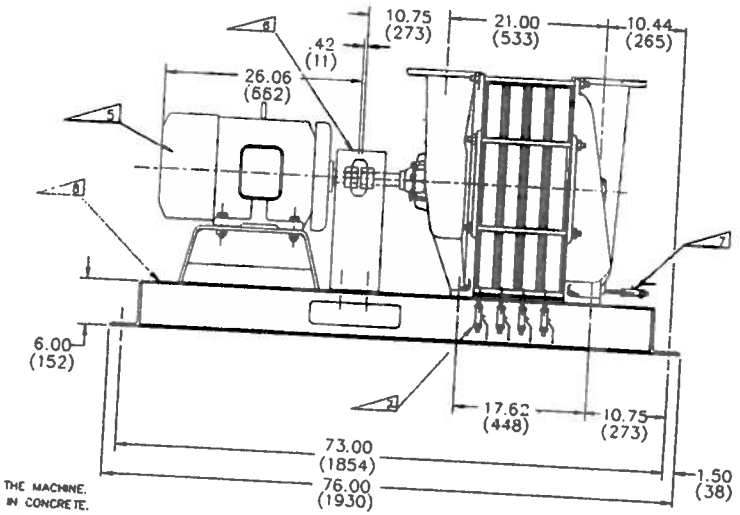
OUTLET

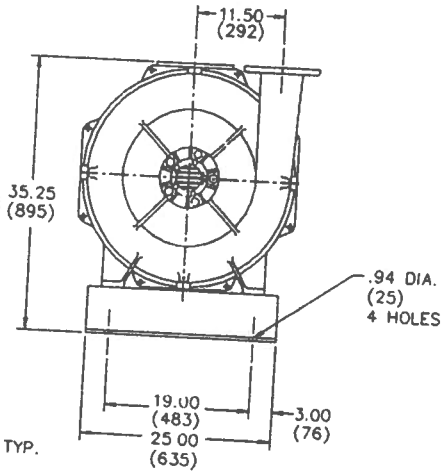


Outlet Positions

VIEWED FROM OUTLET







NOTES:

1. METRIC DIMENSIONS SHOWN IN PARENTHESES, (mm)
2. INLET & OUTLET POSITION 1 STANDARD. INDICATE IF ANOTHER POSITION IS PREFERRED
3. DO NOT BOLT DOWN. IF STUDS ARE USED TO POSITION THE MACHINE, DO NOT FASTEN DOWN WITH NUTS. NEVER GROUT BASE IN CONCRETE.
4. HEADS, SECTIONS & IMPELLERS TO HAVE BISONITE COATING
5. 25 HP, 284TS FRAME, TEFC MOTOR
6. REX OMEGA E-4 COUPLING, W/ ALUMINUM COUPLING GUARD.
7. OUTLET & INTERMEDIATE SECTIONS TO HAVE 3/8 DRAIN CONNECTION W/VALVES
8. BASE & MOTOR PEDESTAL TO BE HOT DIP GALVANIZED

Gardner Denver

LAMSON

LAMSON CONSTANT ENGINEERING GROUP

SCALE	NTS	DATE
DRAWN	RDAC	02/09/98
CHECKED		
APPROVED		

TOLERANCES UNLESS OTHERWISE NOTED

NON-DECIMAL ± 1/16

DECIMALS .XX ±.02 .XXX ±.01

ANGLES ± 1°

DIMENSIONS IN INCHES UNLESS OTHERWISE NOTED

CAST BLOWERS & EXHAUSTERS
510 SERIES

APPROVAL DRAWING
515GD W/25 HP 284TS FRAME

68532M02 | 0D