行政院及所屬各機關出國報告
(出國類別：考察)

參加美國 WEFTEC 2003 水處理設備展並順道拜訪 FLOW SERVE PUMPS 公司及 CATERPILLAR DIESEL ENGINE 工廠心得報告

服務機關：中國石油股份有限公司
油品行銷事業部嘉南營業處工務組

出國人職稱：工程師

姓名：李長青

出國地區：美國洛杉磯

出國期間：92.10.11.~92.10.17.

報告日期：92.12.15.

系統識別號:C09205031

公 務 出 國 報 告 提 要

頁數: 7　含附件: 是

報告名稱:

美國消防公司油庫及加油站油槽火災滅火技術防護設備考察

主辦機關:

中國石油股份有限公司

聯絡人／電話:

葉宇容／87258422

出國人員:

李長青　中國石油股份有限公司　油品行銷事業部　一般工程師

出國類別: 考察

出國地區: 美國

出國期間: 民國 92 年 10 月 11 日 -民國 92 年 10 月 17 日

報告日期: 民國 92 年 12 月 15 日

分類號/目: G2／石油礦及石油工業　G2／石油礦及石油工業

關鍵詞: WEFTEC、液態污染物、回收系統、監控技術

內容摘要: 本事業部負責油料輸儲及銷售等營運工作，油料經由各供油服務中心儲存，再轉運到各航空、汽車或漁船等加油站販售，由於時代之變遷，供油中心及加油站除了位居交通要道外，又越來越接近民房，加上近年來社會輿情及消防、環保等主管機關對於上述場所之消防、安全及污染防制、土壤及水污染改善整治工作等相關規定、益趨重視，因此，為有效推展消防、環保等業務之規劃及防護設備等工作，特奉派赴美國參加WEFTEC 2003水處理設備展，蒐集有關土壤、水處理新技術及設備，並順道拜訪FLOW SERVE PUMPS公司及CATERPILLAR DIESEL ENGINE工廠，實地考察該等之消防設備及法規需求，俾供本事業部參考。

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行政院及所屬各機關出國報告提要

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頁數 7 含附件：☑是□否

出國計畫主辦機關/聯絡人/電話：中國石油股份有限公司油品行銷事業部/人力資源室黃月桂組長/（02）8789-8441

出國人員姓名/服務機關/單位/職稱/電話：李長青/中國石油股份有限公司油品行銷事業部嘉南營業處/工務組/工程師/（05）249-6076

出國類別：☑1 考察□2 進修□3 研究□4 實習□5 其他

出國期間：92.10.11. ~ 92.10.17.　出國地區：美國洛杉磯

報告日期：92.12.15.

分類號/目

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內容摘要：（二百至三百字）

本事業部負責油料輸儲及銷售等營運工作，油料經由各供油服務中心儲存，再轉運到各航空、汽車或漁船等加油站販售，由於時代之變遷，供油中心及加油站除了位居交通要道外，又越來越接近民房，加上近年來社會輿情及消防、環保等主管機關對於上述場所之消防、安全及污染防制、土壤及水污染改善整治工作等相關規定、益趨重視，因此，為有效推展消防、環保等業務之規劃及防護設備等工作，特奉派赴美國參加 WEFTEC 2003 水處理設備展，蒐集有關土壤、水處理新技術及設備，並順道拜訪 FLOW SERVE PUMPS 公司及 CATERPILLAR DIESEL ENGINE 工廠，實地考察該等之消防設備及法規需求，俾供本事業部參考。

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一、前言：

美國 WEFTEC 2003（Water Environment Federation's 76th Annual Exhibition &Technical Conference，2003/10/12~2003/10/15）水設備處理展為美國最大型之展覽，是專為環境、土木、廢水處理、生物學者、化學家、實驗室及相關顧問公司等提供專業性產品之展示，今年參展廠家逾 800 餘家，主要展覽產品包括：

1.化學品和化學處理。
2.工業及有害廢水管理。
3.廢水處理設備/服務。
4.污泥處理/生物污泥管理。
5.輸送管和收集系統。
6.泵、閥和馬達。
7.土壤和地下水整治技術。
8.取樣實驗室設備/服務等。
9.工程設設/技術諮詢服務。
10.儀器、控制設備及自動化。

由於本次參展廠家太多，實在無法於四天內完全參觀完，因此，有關展覽中之大型河川、溝渠污染改善、飲用水紫外線(U.V）殺菌及監控系統，以及其他與本事業部環保業務較無關之產品，僅做概略性了解，而將重點置放於排放或回收水質之處理技術及監測相關設備。

二、本事業部目前液態污染物之處理方式

(一) 廢油污水部分

本事業部目前針對供油服務中心或加油站（含漁船加油站、航空加油站）採用傳統之機械式油水分離或空氣浮除之水污染改善設備處理法，即廢油污水先彙集於油水分離池，經油、水分離或空氣浮除後，再將淨水排放，廢油則抽取後送請高雄煉油廠處理。

(二) 洗車廢水部分

本事業部供油服務中心之油灌車洗車機因使用頻率不高，因此採直接將廢水排放或導入庫區之水污染改善設備處理後排放之方式處理。而加油站部分，洗車放流水除了要求應符合環保法規外，尚有部分營業處正朝洗車機附設廢水回收裝置努力，以達資源回收利用之目的。

(三) 油槽清洗後之廢油泥處理

本事業部油槽清洗（含廢油泥之處理）多委由本公司高雄煉油廠處理。

三、參觀展覽之排放或回收水處理技術設備

展覽現場沒有發現有關廢油泥之大型處理系統，因此僅就廢油污水及洗車廢水之排放或回收系統做介紹，並根據處理方式之不同分為下列三類：

(一) 機械式處理法

1.廢油污水部分

可區分為油水分離池（器）處理及薄膜式處理，其中油水分離器並有不同設計方式，且均已申請專利，與本事業部現行使用之 API 或 CPI 有極大不同，參考型式如附件一、二。薄膜式處理法僅能針對微量之油污進行濾除（附件三），因此可以當作前處理後之第二道濾除裝置。

2.雜物及懸浮物部份

2.1 過濾器濾除裝置

濾除懸浮物或雜物之方式有全自動過濾器（如附件四、五）、半自動過濾器或手動過濾器等，過濾網目則視濾除物大小設置，一般均建議採用 120 mesh 或 180 mesh。另為防止大型異物堵塞，泵輸進入過濾器之輸送廢水泵浦亦建議採用研磨泵（Grinder Pump，附件六）。

2.2 離心式去除裝置

為採用渦流離心式濾除裝置，例如使用 Cyclone 等，於水流上升時，利用渦流離心力將異於水比重之雜物濾除（附件七）。

3.溶氧控制部份

為免靜置之污水發臭，廢水中應溶入足夠之含氧量，因此有泵輸空氣之系統裝置，包含空壓機及於靜置池底之排氣系統（附件八）。

(二) 添加化學品處理

現場展示僅發現兩家（附件九、十），遠低於其他之處理方式，顯示美國對於採用化學品處理方式似較不易為一般企業界所接受，主要原因應為處理後生成物之二次污染再處理問題，以及化學品對於某些水中雜質無法有效處理等。但由於添加化學品處理系統價格低廉，如用在洗車機廢水回收處理上遠較其他處理方式便宜，對於成本考量之台灣業界較有吸引力。目前本公司針對洗車機之廢水處理並未明訂採用方式，僅需符合環保署排放規定即可。針對沉澱生成物之處理則未進一步規定，因此，是否應再規範採用此種型式者之責任（包含廢棄生成物之化驗及處理）等，值得檢討。

(三) 生菌處理方式

為利用自然界中之無害微生物經以附著床及養料彙集後用以吞噬水中之有機物，使達到再利用或可供排放之水質標準（附件十一、十二），對於碳氫化合物之油污，據了解具有極佳之效果。由於此項系統無法消除無機物，因此通常須佐以過濾設備。另如應用於洗車機之廢水回收或排放時，應採用可細菌分解型之清潔劑及水臘（國內目前採用之未經檢測清潔劑等，如未予處理即排放，可能影響地下水水質）。

配合生菌處理之附屬設備較為複雜，除須附有生菌處理槽外，並應有提供空氣之曝氣槽以及其他過濾設備等，因此費用將高出許多，但因微生物取之於大氣，無二次污染之虞，本系統設備已有多家廠家展示，顯示其可利用性，應為本公司考慮應用於排放或回收水處理之系統設備之一。

四、參觀展覽之排放或回收水質監控技術

本類產品展示約有 20 餘家，包括線上型監控及取樣式分析水質。線上型監控對於連續性之排放水系統應有較佳之效果，且可避免人力之浪費，但有增加成本之

考量。美國有關監控系統之廠家，主要監控項目包括 PH 值、導電度、溶氧量、溫度、氯離子含量、硫含量等，並於監視主機上顯示。以上相關參考產品資料如附件十三、十四、十五。

五、順道拜訪 FLOW SERVE PUMPS 公司及 CATERPILLAR DIESEL ENGINE 工廠

（一）92.10.13.

拜訪 FLOW SENVE PUMPS 公司於加洲洛杉磯的 VERNON 工廠，該工廠生產各型水平、直立式泵浦，包括：ANSI,API 及 MAKEN STANDARD 與對方工程師 MR.JIMMY CHEN 討論 UL 及 FM 對 FIRE FIGHTING 泵浦之有關規定及需求（詳見附件十六、十七 UL 及 FM 規定）。

（二）92.10.14.

繼續拜訪 FLOW SERVE PUMPS 公司於加洲洛杉磯的 VERNON 工廠，參觀水平式的 10LR15 型的 FIRE FIGHTING 泵浦測試，該測試由 VERNON 工廠的馬達帶動，所有資料、泵浦流量、流程、馬達電流、泵浦效率完全由電腦記錄後印出，另外參觀直立式的 14H19 型的 FIRE FIGHTING 泵浦測試，該測試由柴油引擎聯接 RIGHT ANGLE GEAR 帶動泵浦、泵浦的流量、揚程、效率亦由電腦紀錄後印出（詳見附件十八、十九直立及水平式泵浦型錄及測試規定）。

（三）92.10.15.

拜訪 CATENPILLAR 柴油引擎在洛杉磯的組裝，維修工廠，該工廠除了組裝工業用柴油引擎外，亦提供客戶作 "PACKAGING"的服務，即可提供整組柴油引擎發電機組，整組柴油引擎消防泵浦機組等等，另外該工廠亦提供柴油引擎修理之售後服務（詳見附件二十柴油引擎型錄）。

六、結論及建議：

（一）本公司為石化業之龍頭，因此有關環境保護工作應有帶頭之責任。根據本次之展覽參觀，國外對於水資源或地下水之重視由展示之各項產品可略窺一二，因此對於本事業部供油服務中心及加油站地下水之污染防治及監控，亦應多參考國外之處理方法，進而落實我們的環境保護工作。

（二）本事業部供油服務中心及加油站有關廢油污水之處理，包括油水分離池經分離後之排放水及洗車機之廢水回收或排放等，其回收或排放水品質是否已達世界各先進國家之嚴格標準，確實值得我們關心。本事業部目前對於回收或排放水品質之處理及監測，以現行之機械方式處置似嫌不足，因此加強改善處理方式以及增加改善水質之監控設備，為未來之環保工作重點之一。

（三）本次展覽以美、加產品居多，歐洲參展廠家非常有限（估計未及 20 家），而歐洲土地狹窄，自然環境水資源更形重要，建議本事業部應可派遣專業人員參與歐洲地區類似之展覽，以收取"他山之石"之實務經驗，應用於同屬高人口密度之台灣。

（四）洗車機所採用之洗潔劑及水臘等，根據國外廠家之說明，應具有環保無污染且可供細菌分解之特性，以免影響地下水質。未來本事業部洗車機之採購，以及洗潔劑、水臘和廢水回收或排放系統之規定，似應有整體之考量並制定標準規範，俾免承商於環保之疏失造成本公司名譽之傷害，如洗潔劑、水臘或化學劑（如採用添加化學藥劑處理方式）等均應提出詳細之物質安全資料表（MSDS）及說明對環境影響及處理方式等，並應依環保規定申請環境用藥許可。

針對本公司油槽消防系統之改善建議如下：

儲油槽的型式主要可分為二種型式：1、固定錐頂油槽。2、浮頂油槽。

油槽儲放大量的燃料，因此消防系統的設置是十分的重要，以在火災發生時能在最短的時間內將火災撲滅，將損失降至最低。目前油槽最普遍使用的消防系統為固定泡沫系統。油槽的泡沫系統設計時依油槽的尺寸大小、儲存的燃料種類來進行消防系統的設計，除了將足夠泡沫量在設計噴放時間內直接注入油槽中，以將火災撲滅外，亦需在現場提供足夠的泡沫量供消防泡沫水帶使用(流量至少 50 加侖/分鐘)以撲滅地面上的火災或保護其他的設備使用。目前固定的泡沫消防系統多數使用衡壓式的泡沫系統，泡沫原液儲存於囊袋式的泡沫槽中，當油槽火災發生時，若原設置的泡沫系統的泡沫原液使用完但仍無法有效將火勢控制時，囊袋式的泡沫槽並無法立即再充填原液以供消防系統使用，此時必需依靠其他的消防設備來進行滅火工作。

ANSUL 除提供高品質的固定泡沫系統外，另提供多種移動式的泡沫系統，以強化固定泡沫系統的功能或作為消防泡沫水帶的緊急供應源。火災發生時，除固定式的泡沫系統動作外，泡沫消防車也需到現場同時撲滅火災或保護其他重要的設備，也是不可欠缺的消防設備。但一般泡沫消防車的造價高，因此大量採購會需要一筆龐大的費用，且車輛需日常的保養，才能維持泡沫消防車的功能，也是一筆費用。要強化消防系統並降低設備的支出，ANSUL 移動式消防系統是提供最佳的解決方案。

ANSUL 移動式消防系統是將系統安裝在拖車上，可加掛在一般車輛或消防車上，拖到火災現場，以提供更大的滅火效能。ANSUL 移動式消防系統的造價及保養費用比消防車低相當的多。

ANSUL 移動式消防系統主要分為二種：1、泡沫原液拖車。2、泡沫乾粉雙藥劑消防拖車。

泡沫原液拖車主要由泡沫原液槽、自吸式比例混合器及泡沫砲台所組成。泡沫原液槽可裝填 275 加侖的泡沫原液。砲台有多種流量可以選用，使用時只要在比例混合器上接上現場的消防水即可以使用。泡沫原液在使用中可以不斷地加入原液槽內，連續使用不必中斷。

泡沫乾粉雙藥劑消防拖車主要由乾粉儲槽、泡沫液儲槽、氮氣鋼瓶、高壓軟管及雙藥劑噴嘴所組成。泡沫加乾粉是撲滅 B 類火災有效的方法，除可將火勢撲滅外更可以有效防止回火的產生。泡沫乾粉雙藥劑消防拖車可以用於撲滅地面的油類火災或開闢救火或搶救人員、設備的路線，其最大可以撲滅 6,000 平方英呎的火災面積。

ANSUL 提供完整的消防設備給各種不同的場所使用，移動式的消防系統是強化油槽消防系統或其他高風險的場所消防系統的最佳選擇。

七、附錄：

（一）附件一：美 Highland Tank 公司油水分離池

（二）附件二：美 Jay R. Smith Mfg.公司地上式及地下式油水分離池

（三）附件三：美 Zenon Environmental 公司薄膜式濾除設備

（四）附件四：美 Automatic Filters 公司全自動過濾器（含逆洗系統）

（五）附件五：美 Amiad Filtration 公司全自動過濾器

（六）附件六：美 Zoeller 公司研磨泵

（七）附件七：美 Enviro Voraxial Technology 公司離心式濾除雜質系統

（八）（八）附件八：美 MixAir Technologies 公司溶氧系統

（九）附件九：美 Carus Chemical 公司水處理化學藥劑

（十）附件十：美 Arch Chemicals 公司水處理化學藥劑

（十一）附件十一：美 USFilter 公司生菌處理廢水系統

（十二）附件十二：加 Waterloo Biofilter Systems 公司生菌處理廢水系統

（十三）附件十三：美 Ionics 公司線上水質分析儀

（十四）附件十四：德 Wissenschaftlich-Technische 公司線上水質監測系統

（十五）附件十五：美 Horiba 公司水質測量儀器

（十六）附件十六：UL GUIDE INFORMATION FOR FIRE PUMP

（十七）附件十七：FM APPROVALGUIDE FOR FIRE PUMP

（十八）附件十八：VERTICAL PUMP TEST PROCEDURE

（十九）附件十九：HORIZONTAL PUMP TEST PROCEDURE

（二十）附件二十：HORIZONTAL，VERTICAL PUMP&DIESEL ENGINE CATALOGUE

附件一 美 Highland Tank 公司油水分離池

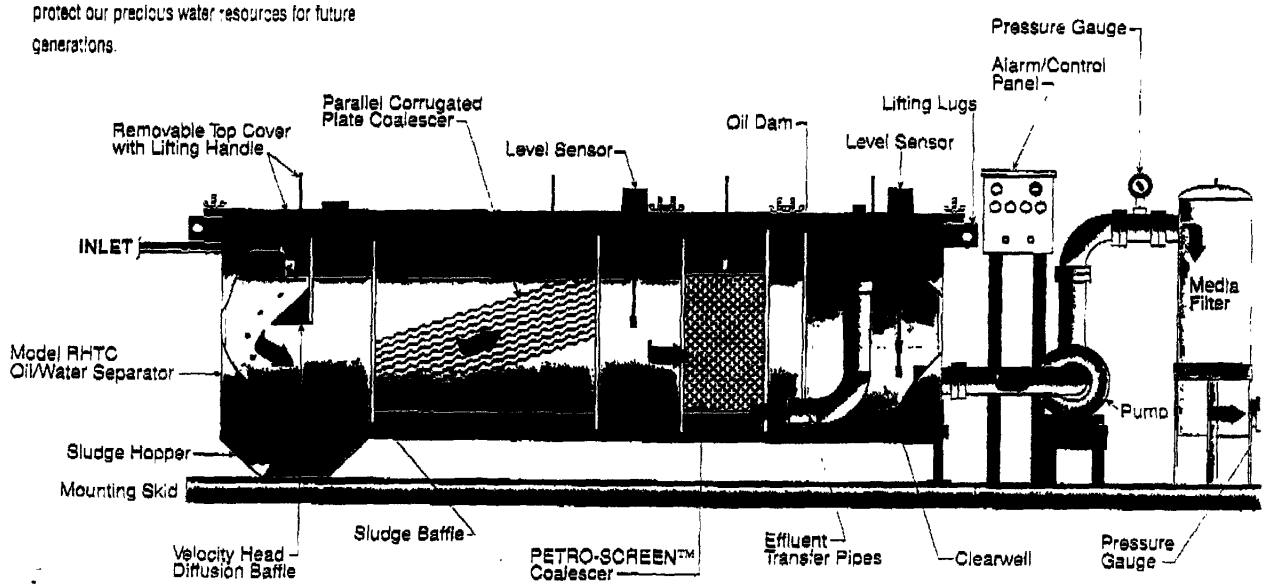
Highland ASTS - Advanced Secondary Treatment Systems

Working Toward A Clean Environment

The conservation of global water resources has directly affected industries worldwide. They are now facing more stringent regulations covering the discharge of oily wastewater. Public pressure placed on governments to control harmful oil spills and pollutant discharges has resulted in costly penalties to industries. The goals of these regulations are the drastic reduction of water pollution and the achievement of high water quality standards to protect our precious water resources for future generations.

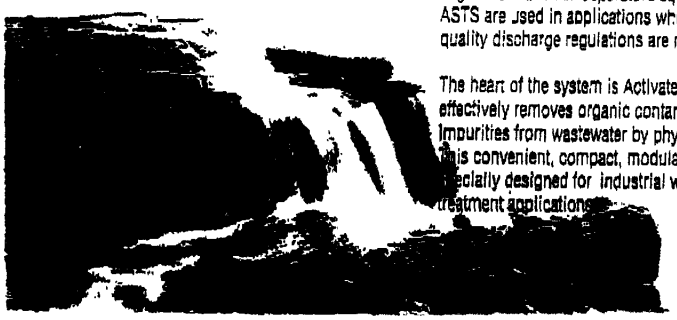
Highland Tank has a proven history of offering innovative solutions for industrial wastewater discharge problems. Twenty years ago Highland Tank introduced its patented oil/water separators. Since then, Highland Tank has developed a record of reliability with thousands of high performance separators in commercial operation worldwide.

Our dedication to the environment and commitment to our customer's needs has driven the Highland mission of providing better oil/water separator solutions. The development of our Advanced Secondary Treatment System takes our record of reliability to a new leve



Highland Tank Oil/Water Separators are patented in the United States under Patent #4,722,800 and in Canada under Patent #1,296,263.

Illustration shown is an example of an aboveground installation



Advanced Secondary Treatment System

Highland Oil/Water Separators equipped with the ASTS are used in applications where strict water quality discharge regulations are mandated.

The heart of the system is Activated Clay which effectively removes organic contamination and impurities from wastewater by physical adsorption. This is convenient, compact, modular system is specially designed for industrial wastewater treatment applications.

Typical Applications:

- Industrial facilities
- Military installations
- Oil and gas wells
- Refineries
- Petroleum marketing facilities
- Railroads
- Utility switch yards
- Vehicle maintenance shop service bay and fueling area drainage
- Contaminated groundwater and surface water remediation from leaking petroleum storage tanks and piping at:
  - Bulk storage tank farms
  - Gasoline service stations
  - Hazardous waste sites

附件二 美 Jay R. Smith Mfg.公司地上式及地下式油水分離池

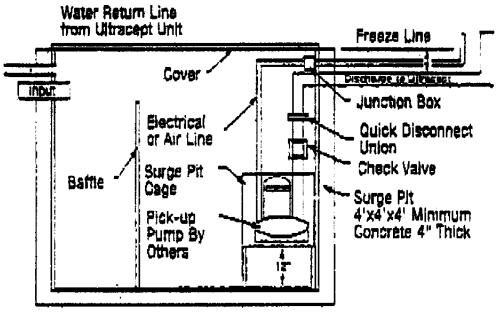
When meeting discharge requirements is the problem...

The ULTRACEPT® Process

The Jay R. Smith Mfg. Co. Ultracept® Oil/Water Separation System, Figure #8602-8645, is an above ground unit. It is one of the simplest, most efficient systems available to remove free oil from waste water without the use of filters and coalescing plates.

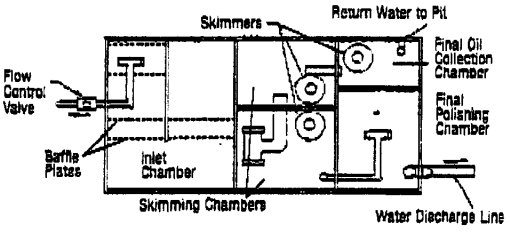
Surge Pit Description and Sketch

The minimum size for a surge pit is 4' x 4' x 4', which equals to approximately 450 gallon capacity, however, the larger the better. In some cases, existing tanks or underground separators can be used. When possible, a baffled surge pit, as illustrated, is recommended.



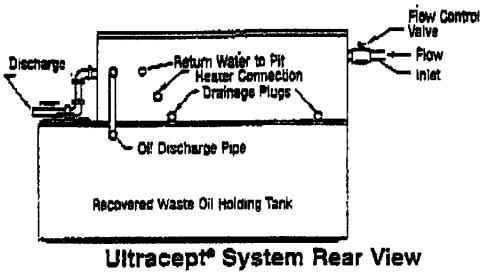
Baffled Surge Pit

From a surge pit, either above or below grade, contaminated water is pumped to the Ultracept® Oil/Water Separator. The separator, having been filled with clean water prior to start-up, then uses the surface tension of the clean water to promote and enhance waste separation. The water then travels through a series of chambers for gravity discharge to a sanitary sewer or to a recycling system. Through a unique skimming technique, the Ultracept® System isolates the waste for easy removal.



Ultracept® System Top View

This is a top view of the basic Ultracept® Oil/Water Separator with waste oil holding chamber.



Ultracept® System Rear View

This shows the back of the Ultracept® Oil/Water Separator with the optional recovered waste oil holding tank. This model is recommended for situations that may have the potential of spills such as refueling areas.

Options

- Heater for Freeze Protection
- Supply Pumps
- Polishing System
- Recycling System
- Trailer
- Hydrocarbon Encapsulation System, Figure #8600

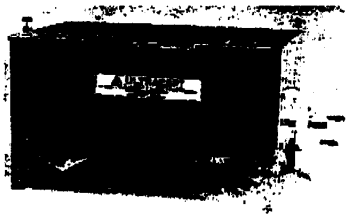


Figure #8605-03S

Figure #8605-03ST

Figure #8605-03F

The Ultracept® System designs are flexible. Shown are the stainless steel and fiberglass models, both on and off the optional trailer. Ultracept® Systems in Stainless Steel are available with flow rates of 2, 3, 5, 10, 25, and 45 GPM. Fiberglass units are only available in 3 and 5 GPM. For higher flow rates, units can be installed in parallel. Please contact your Ultracept® representative for proper sizing. All sizes can be set up as portable units.

Ultracept® Systems are shipped with all internal plumbing and necessary drainage fittings installed.

附件二 美 Jay R. Smith Mfg.公司地上式及地下式油水分離池

The ULTRACEPT® System from Jay R. Smith Mfg. Co. is the solution.

Service and Maintenance

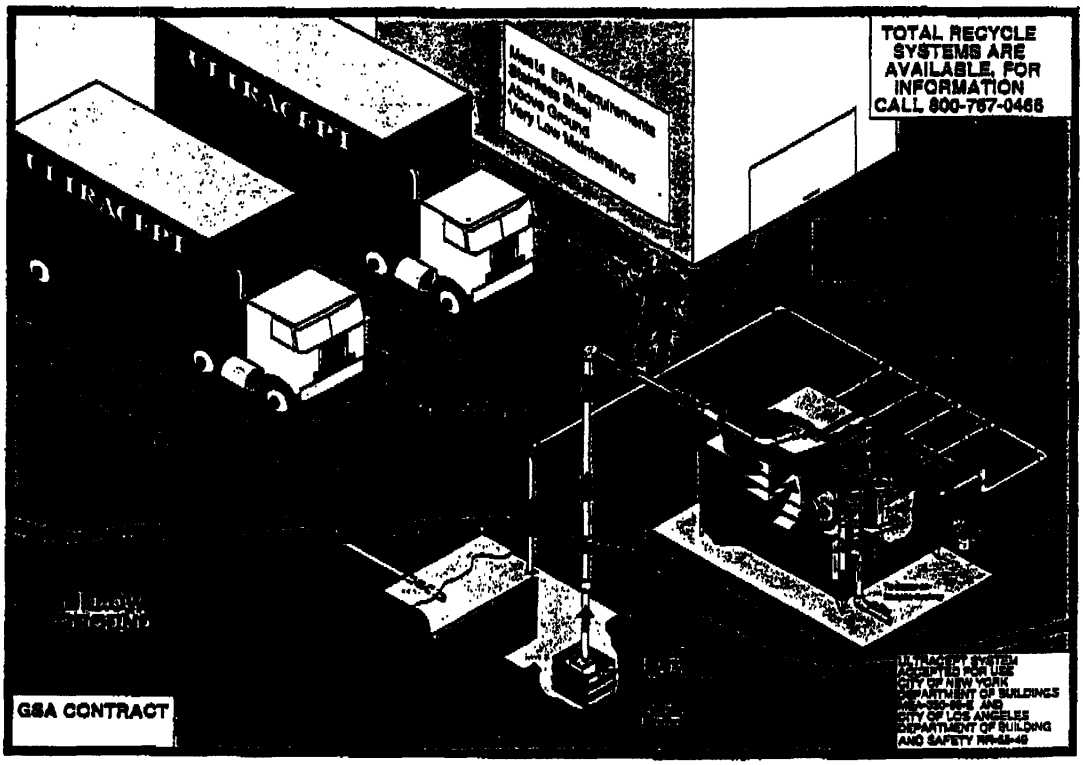
The purpose of your Ultracept® Oil/Water Separator System is to give you clean water that will meet your requirements no matter how stringent they may be.

Since there are **No Moving Parts, No Coalescing Plates** to clean and **No Filters** to change, suggested maintenance is less than 10 minutes a week. Discharges under 10 PPM have been achieved.

We have knowledgeable representatives throughout the country who are available to assist you at anytime or call 1-800-767-0466.

How the ULTRACEPT® System can work for you.

Truck/Maintenance Shop and Wash Area



Features and Benefits:

- Solutions with simplicity
- Flow rates from 2 to 45 GPM
- Collected waste oil has negligible water content
- Waste oil isolated for easy removal
- No coalescing plates, filters, moving parts, or chemicals
- Simple installations, on-grade or portable system
- Stainless Steel, Mild Steel with bitumastic finish or Fiberglass fabrication
- Modular units for simple upgrade
- New York City and Los Angeles City Approvals

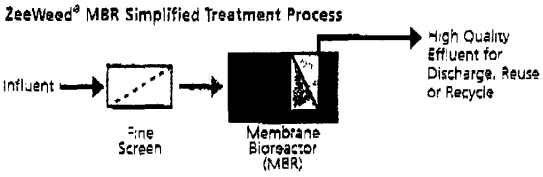
附件三 美 Zenon Environmental 公司薄膜式濾除設備

What is ZeeWeed® MBR?

ZeeWeed® MBR, developed by ZENON Environmental Inc., combines membrane technology with biological treatment for municipal and industrial wastewater applications. The system replaces conventional treatment and combines clarification, aeration and filtration into a simple and cost-effective process that reduces capital and operating costs. The result is consistent, high quality effluent suitable for any discharge or reuse application.

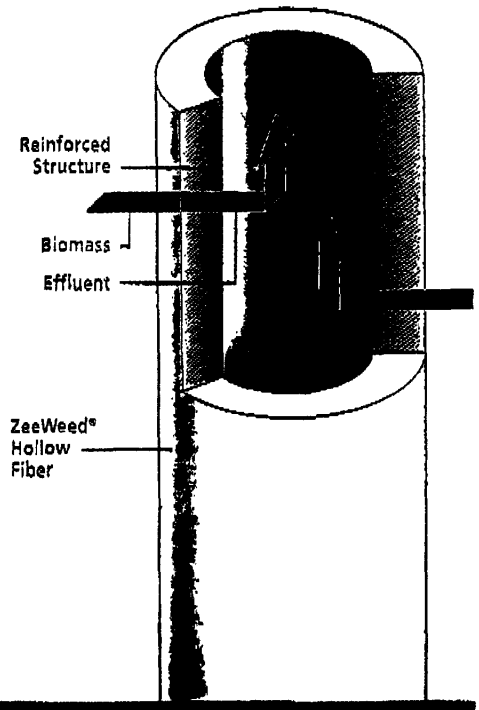
Conventional Multi-Step Tertiary Treatment Process

ZeeWeed® MBR Simplified Treatment Process



The Key to ZeeWeed® MBR

Most membranes cannot operate in a high solids environment. They were designed for other purposes such as drinking water filtration. ZeeWeed® MBR uses reinforced hollow fiber membranes specifically designed to meet the requirements of wastewater treatment. The ZeeWeed® membrane is the strongest on the market and will not fail. No other membrane can compare for reliability and operating life.



The ZeeWeed® immersed membrane operates under a slight suction, drawing clean water to the inside of the membrane fiber (outside-in flow path), while leaving biomass and impurities in the process tank.

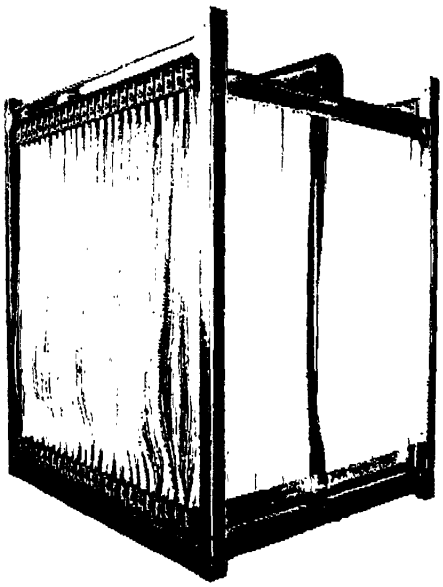
ZENON – THE LEADER IN MBR FOR MORE THAN TWO DECADES

1980 – 1990	1990	1993	1994	1998
ZENON successfully pioneers tubular MBR systems	ZeeWeed® Reinforced Membrane™ developed	1st full-scale plant	1st industrial ZeeWeed MBR plant	1st retrofit WWTP – 1 (5,300 m³/

附件三 美 Zenon Environmental 公司薄膜式濾除設備

The ZeeWeed® MBR Advantage

- ZeeWeed® membranes provide a physical barrier to particulate discharge, resulting in better than tertiary quality effluent, suitable for direct reuse or discharge.
- Compact footprint. ZeeWeed® Reinforced Membranes™ are immersed directly in the bioreactor, resulting in systems that are much smaller in size than conventional tertiary plants.
- Aerobic process that produces minimal odors.
- Produces ideal reverse osmosis feed water with an SDI < 3.
- Cost competitive with conventional technologies.
- Simple and efficient design.
- In-situ cleaning simplifies system operation and maintenance.



ZeeWeed® Reinforced Membrane™ Cassette

ZeeWeed® MBR Outperforms Conventional Systems

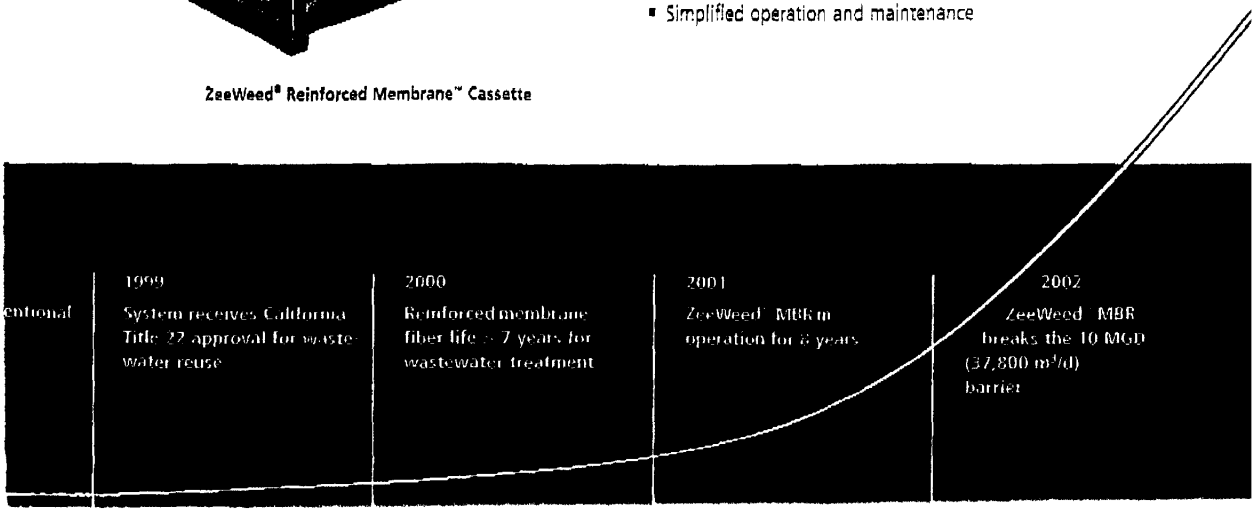
Higher Quality Effluent	
Parameter	**Effluent Quality**
BOD_5	< 2 mg/L
TSS	< 2 mg/L
Ammonia	< 1 mg/L
TN	< 10 mg/L*
TP	< 0.1 mg/L**
Turbidity	< 0.1 NTU
SDI	< 3

* with anoxic zone
** with coagulant addition

	ZeeWeed® MBR	Conventional Tertiary Treatment
Clarifier	No	Yes
Filter	No	Yes
MLSS	> 10,000 mg/L	< 5,000 mg/L
SRT	10-100 days	< 10 days
Footprint	Typically 4-5 times smaller	
Process Stability	Not susceptible to upsets	Susceptible to sludge bulking

In 1990 ZENON pioneered the ZeeWeed® Reinforced Membrane™ which set new standards for membrane technologies. The benefits of ZeeWeed® include:

- Low fouling, easy to clean
- Longer membrane life
- Fail safe membrane due to reinforced structure
- Much higher tolerance for solids
- Simplified operation and maintenance

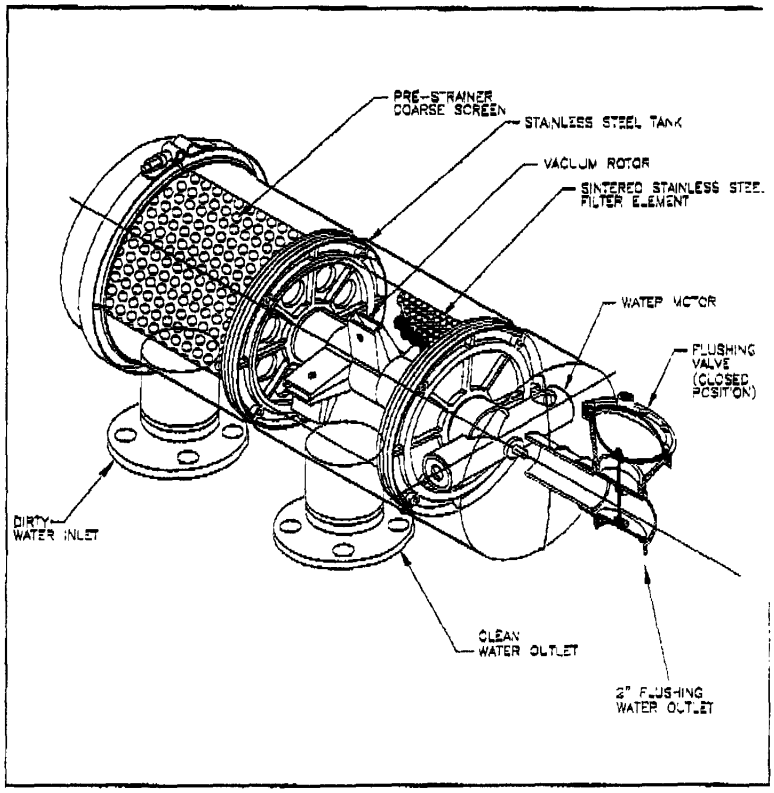


附件四 美 Automatic Filters 公司全自動過濾器（含逆洗系統）

Filter Operation

FILTER OPERATION

Tekleen® filters are self cleaning and operate on line pressure alone. As water passes through the filter the dirt particles are collected on the screen. This causes a drop in water pressure. When the pressure drop reaches a preset level the cleaning cycle is initiated. The Vacuum Screen Cleaner aggressively suctions the dirt from the inside of the screen and flushes it out the drain. The backwash cycle is accomplished in seconds without interrupting the main flow. The compact systems are available in a wide range of industrial configurations.

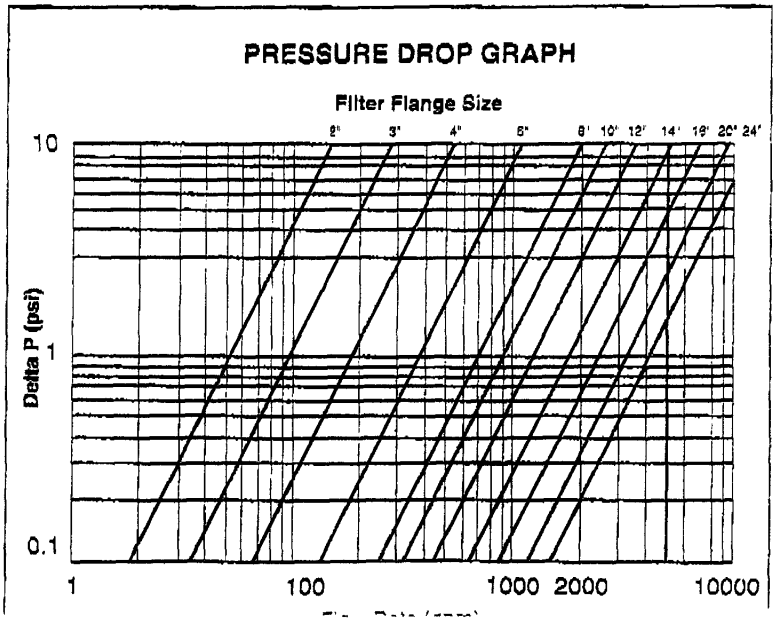


STANDARD FILTERS

- Fully automatic self-cleaning mechanism.
- No external power required.
- No flow interruption during backwash.
- No screen removal for manual cleaning.
- Minimum pressure - 35psi.
- Maximum pressure - 150psi.
- SST filters at carbon steel prices (2", 3", 4").

OPTIONAL FEATURES

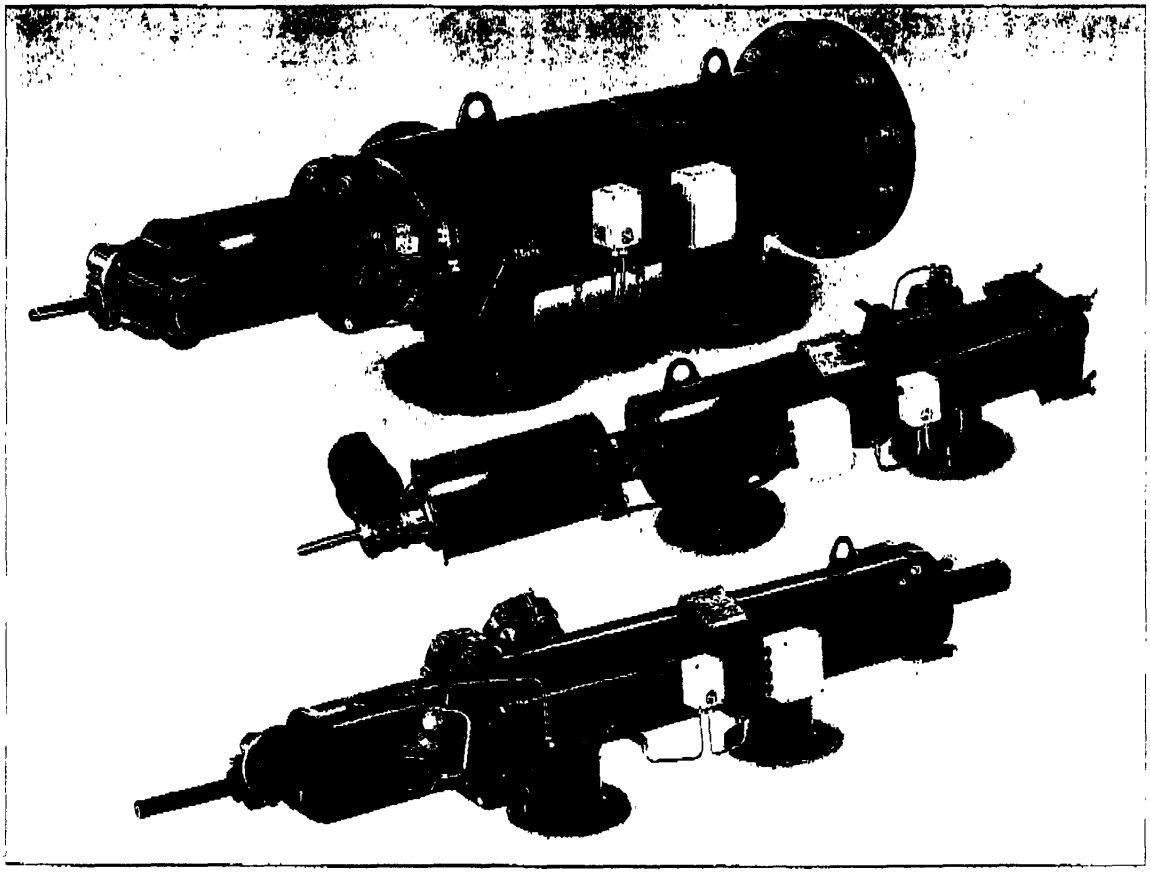
- Unlimited flow capacities.
- ASME coded body.
- High Performance Screens.
- 5 micron filtration.
- High dirt loads to 1,000 ppm.
- High pressure up to 600psi.
- High Temperature up to 250ºF.
- Coarse screen flushing pre-



附件五 美 Amiad Filtration 公司全自動過濾器

AMIAD SAF Filter Series

2"-10" Automatic Filters for flow rates up to 1760 USgpm



- 1760gpm per unit. Units can be manifolded together for any size application
- Filters use less than 1% of total flow required for flushing
- Multiple options for body materials and coatings can be used on fresh, brackish and sea water applications
- Filtration degrees range from 500 - 10 Micron
- Flushing can be set according to pressure differential and/or time with sophisticated control options such as alarm, by-pass, pump operation, etc.

附件六 美 Zoeller 公司研磨泵

2 HP GRINDER PUMP SERIES

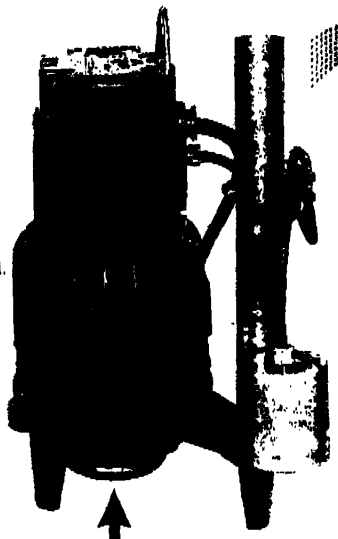
6820 GRINDER PUMP
FOR RESIDENTIAL APPLICATIONS

UNIQUELY DESIGNED PUMP WITH INTEGRAL CONTROL

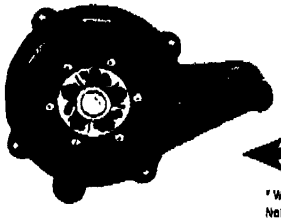
STANDARD FEATURES:
- 1¼" NPT Vertical Discharge
- Carbon/Ceramic Mechanical Seal
- Thermal Overload protection
- Balanced Bronze Impeller
- Stainless Steel Cutter Plate/Cutter
- Stainless Steel Shaft
- Stainless Steel Hardware
- 20 ft. Power Cord
- Submersible motor, 2 HP, 60 Hz, 3450 RPM
- Corrosion resistant powder coated epoxy finish.

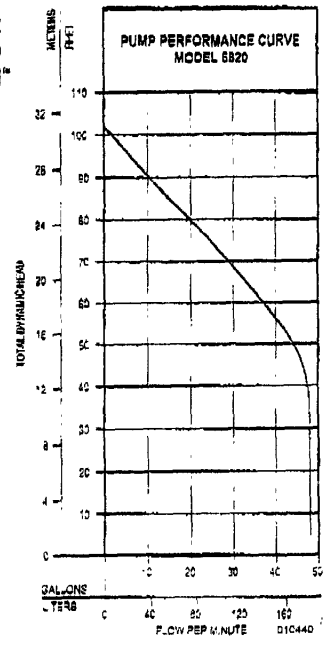
Tested to U.L. Standard UL778

POWDER COATED TOUGH™



OPTIONS:
- Silicon Carbide/Carbon Mechanical Seal
- Extra Length Cords
- Non-Automatic Model





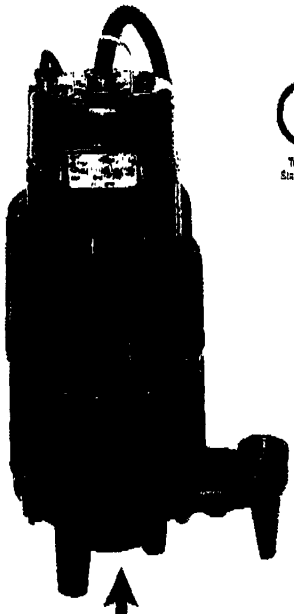
* WD & WH grinder pumps are completely automatic with starting controls in pump switch case. Nonautomatic also available

6840 GRINDER PUMP
(With Bi-Directional Cutter)

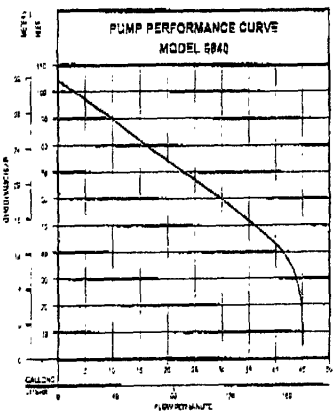
STANDARD FEATURES:
- Reversible Cutter Action Manual or Auto**
- Carbon/Ceramic Tandem Seals
- Class F Insulated Motors
- Thermal Sensors** (O.L. on 1PH)
- Moisture Probes**
- Balanced Bronze Impeller
- Stainless Steel Cutter and Plate (R-C 55-60)
- Stainless Steel Shaft
- Corrosion resistant powder coated epoxy finish.
- 20 ft. Power Cord
- 20 ft. Sensor Cord
- UL Listed
- Submersible motor, 2 HP, 60 Hz, 3450 RPM

***Requires Circuit in Control Panel to Function*

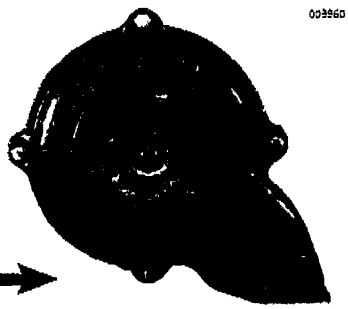
OPTIONS:
- Silicon Carbide Seal(s)
- Extra Length Cords
- Trimmed Impeller



Tested to U.L. Standard UL778



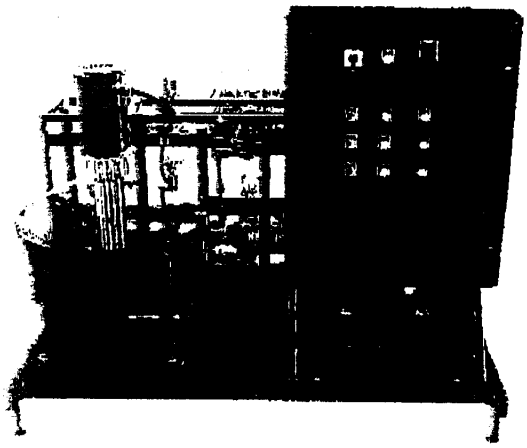
POWDER COATED TOUGH™



附件七　美 Enviro Voraxial Technology 公司離心式濾除雜質系統

ENVIRO VORAXIAL TECHNOLOGY

COMPLETE LINE OF COMPOSITE SEPARATORS



VAS1000 COMPOSITE SEPARATORS
(5GPM)

VAS2000 COMPOSITE SEPARATORS
(25GPM/50GPM/100GPM)

VAS4000 COMPOSITE SEPARATORS
(500GPM)

The resource recovery field takes a leap forward with the successful joining together of the two leading methods of oil-water separation into one composite system. The 400% increase in flow-thru capability resulting from joining the highly efficient, patented Voraxial Separator with a conventional centrifuge results in an oil separator system more effective than any other in the market today.

MISSION STATEMENT

EVTN will create environmental a
industrial solutions that efficient
separate and treat various was
streams and return clean water to t
environment while improving t
productivity and profitability of o
customers' operations.

EVTN

A Growing Leader in
Environmental and Industrial
Separation Technology

附件七 美 Enviro Voraxial Technology 公司離心式濾除雜質系統

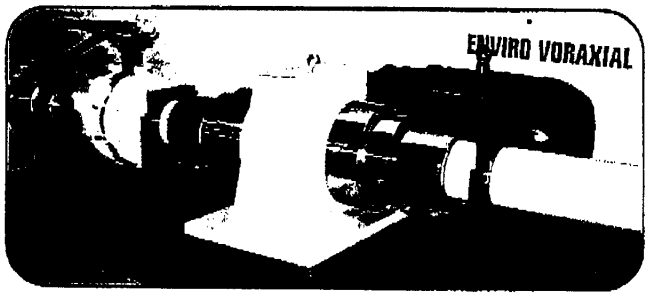
EVTN - A Growing Leader in Environmental and Industrial Separation Technology

EVTN's patented Voraxial Separator ("VAS") is a cost-efficient, continuous flow separator that simultaneously separates liquid/liquid, liquid/solid and liquid/liquid/solid mixtures flowing through the separator at heretofore unheard of high flow rates.

The Voraxial Separator is fitted with a patented, non-clog, low-shear impeller designed to create a vortex in the fluids flowing through the separator. By this action, heavier materials are forced to the outside of the vortex while lighter materials are drawn to form the central core of the vortex, thereby creating separated flow streams. A specially designed manifold is utilized at the exit of the separation chamber to collect the separated streams.

CHARACTERISTICS OF THE VORAXIAL SEPARATOR

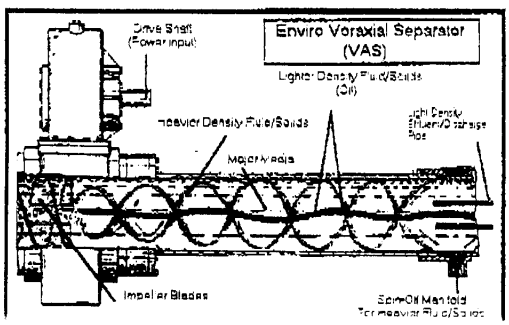
- **Scaleable - The Voraxial Separator can be manufactured to handle any volume.**
- **Clog-free - Open impeller design makes the Voraxial Separator virtually clog-free.**
- **Low shear - Specially designed impeller produces low-shear performance.**
- **Compact - The Voraxial Separator requires a small footprint to handle large volumes.**



VAS4000 VORAXIAL SEPARATOR
(250 GPM to 900 GPM)

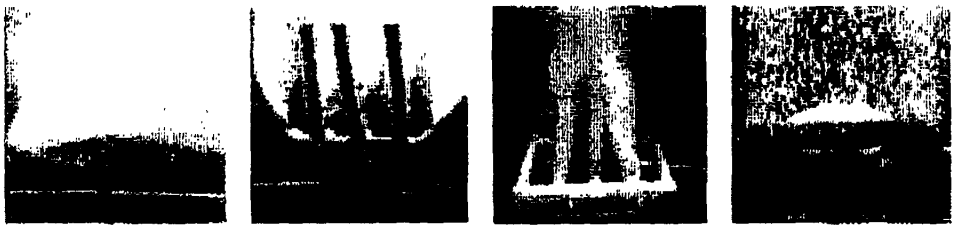
VAS8000 VORAXIAL SEPARATOR
(2000 GPM to 8000 GPM)

- **Specially designed for 2-way separation (liquid/liquid and liquid/solid) and 3-way separation (liquid/liquid/solid).**



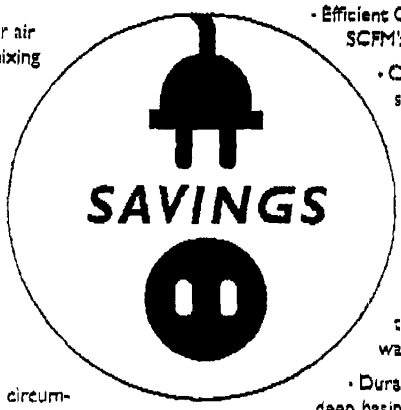
附件八 美 MixAir Technologies 公司溶氧系統

Features of MixAir Diffusers



MixAirTech Diffusers Lead To One Thing...

- Design allows liquid to completely surround membrane and efficiently release fine bubbles
- Configured for high oxygen transfer and consistent mixing
- Designed to efficiently aerate and mix shallow and deep bodies of water
- Unique design allows for higher air flow which causes increased mixing
- Easy installation
- Low maintenance
- High efficiency means reduced power costs
- Efficiency generates fine bubbles with extremely low backpressure at high SCFM
- Unique design maximizes the volume of liquid moved between diffuser elements
- Emits fine bubbles from entire circumference of membrane, providing for maximum O_2 transfer
- Maximizes air transfer and mixing with the same power source
- Micro-porous membrane design keeps fine bubbles from coalescing all the way to the surface
- Reduces energy costs
- Reduces and controls odors through efficient O_2 uptake and uniform mixing



- Provides maximum pounds of O_2 per horsepower per hour
- Easily adaptable to most conventional blower systems
- Transfers significantly more O_2 per horsepower than other aeration devices
- Efficient O_2 transfer at low PSI and high SCFM's
- Continuous membrane maintains small bubble size even at high SCFM
- Membrane requires minimal PSI to operate efficiently while maximizing O_2 transfers
- Designed for easy retrofit and installation
- Manufactured to withstand the harsh environments found in wastewater treatment applications
- Durable membrane is suitable for deep basin applications
- Device efficiency allows for quick payback of capital expenses through electrical cost savings
- Design allows for equal air distribution over entire membrane
- Effectively destratisfies bodies of contaminated water promoting increased biological activity and controlling odor
- Unique design creates large zones of influence

附件九 美 Carus Chemical 公司水處理化學藥劑

CARUSOL™-20

Sodium Permanganate
CAS No. 10101-50-5

Fact Sheet

CARUSOL™-20 sodium permanganate is an oxidant recommended for drinking water, wastewater or industrial applications that requir a concentrated permanganate solution. Applications include iron & manganese, taste & odor, disinfection by-product reduction, odc and corrosion control, hazardous waste treatment, toxic pollutant destruction and biological improvement.

Product Specifications

Assay	20% as $NaMnO_4$
pH	6.0 - 9.0
Specific Gravity	1.16
Solubility in Water	Miscible with water in all proportions.

Chemical/Physical Data

Formula	$NaMnO_4$
Appearance	Dark Purple Solution
Insolubles	100 - 1900 ppm
Stability	> 18 Months

Applications

- Drinking Water Purification
  - Iron/Manganese Oxidation
  - Taste and Odor Control
  - Preoxidant for THM Control
  - Hydrogen Sulfide Control
- Municipal Wastewater
  - Hydrogen Sulfide Odor Control
  - Improves Sludge Dewatering
  - Toxic Pollutant Destruction
  - Toxicity Reduction
- Industrial Applications
  - Hydrogen Sulfide Odor Control
  - Phenol Destruction
  - COD/BOD Reduction
  - Toxicity Reduction

Benefits

- Concentrated liquid oxidant is easily stored and handled.
- Feed equipment is simplified (no need to transfer and dissolve crystalline product).
- Dust problems associated with handling dry oxidants are eliminated.

Shipping Containers

5 gallon (18.9L) Tight Head HDPE Jerrican
(UN Specification: 3H1) made of High Density Polyethylene (HDPE), weighs 3.5 lb (1.6 kg). The net weight is 45 lb (20.5kg). The jerrican stands approximately 15.33 in. tall, 10.2 in. wide and 11.4 in. long (38.94 cm tall, 25.91 cm wide, 28.96 cm long).

55 gallon (208.2L) Closed HDPE Drum
(UN Specification: 3H1) made of High Density Polyethylene (HDPE). Weighs 20.5 lb (9.3 kg). The net weight is 550 lb (249.5 kg). The drum stands approximately 35.1 in. tall, has an outside diameter of 23.4 in. (89.1 cm tall, OD 59.4 cm).

250 gallon (946.25L) Totes
Weighs 143 lb (65 kg). The net weight is 2300 lb (1043.1 kg). The tote dimensions are 46 inches high, 48 inches long and 40 inches wide. The tote has a Red Handled VL Ball Valve with NPT Threads and a foil seal.

Handling and Storage

Like any strong oxidant, CARUSOL™-20 liquid permanganate should be handled with care. Protective equipment during handling should include face shields and/or goggles, rubber or plastic gloves, rubber or plastic apron. If clothing becomes spotted, wash off immediately; spontaneous ignition can occur with cloth or paper. In cases where significant exposure exists, use of the appropriate NIOSH-MSHA dust or mist respirator is recommended.

The product should be stored in a cool, dry area in closed containers. Concrete floors are preferred. Avoid wooden decks. Spillage should be collected and disposed of properly. Contain and dilute spillage to approximately 6% with water and reduce with sodium bisulfite. Deposit sludge in an approved landfill or, where permitted, drain into sewer with large quantities of water.

As an oxidant, the product itself is non-combustible, but will accelerate the burning of combustible materials. Therefore, contact with all combustible materials and/or chemicals must be avoided. These include, but are not limited to: wood, cloth, organic chemicals, and charcoal. Avoid contact with acids, peroxides, sulfites, oxalates, and all other oxidizable inorganic chemicals. With hydrochloric acid, chlorine is liberated.

For further information on CARUSOL™-20 sodium permanganate product characteristics and availability, contact Carus Chemical Company at 1-800-435-6856.

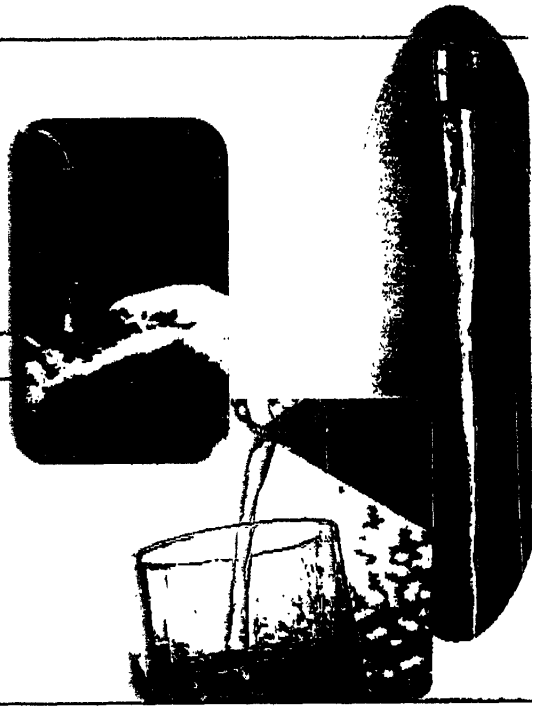
CARUS CHEMICAL COMPANY

附件十　美 Arch Chemicals 公司水處理化學藥劑

Constant Chlor® Plus Briquettes

Constant Chlor® Plus Briquettes are designed for use in the Constant Chlor® Chlorinator. The briquettes provide chlorine solution for use in many applications including the treatment of surface and groundwater for municipal drinking water use, as well as the treatment of wastewater effluent.

These patented, pillow-shaped briquettes contain a scale inhibitor that dramatically reduces the potential for scale build-up frequently associated with the use of calcium hypochlorite.



Features

Dry Solid Product

- Longer shelf life than liquid bleach
- Occupies much less space than liquid bleach
- Less hazardous than liquid bleach
- Easier to handle than liquid bleach

Scale Inhibited

- Patented formulation
- Reduces maintenance of equipment

Typical Properties

Available chlorine (% by weight)	66.0%
Scale inhibitor (% by weight)	0.5%
Weight (grams)	7 grams (7.0 grams)
Dimensions	1 1/4 in x 1 in x 1/2 in (approx. 35mm x 24mm x 12mm)
Appearance	Pillow-shaped briquettes

Regulatory

- EPA No. 1258-1179
- NSF Standard 60, Drinking Water Additives
- Meets AWWA Standard B300

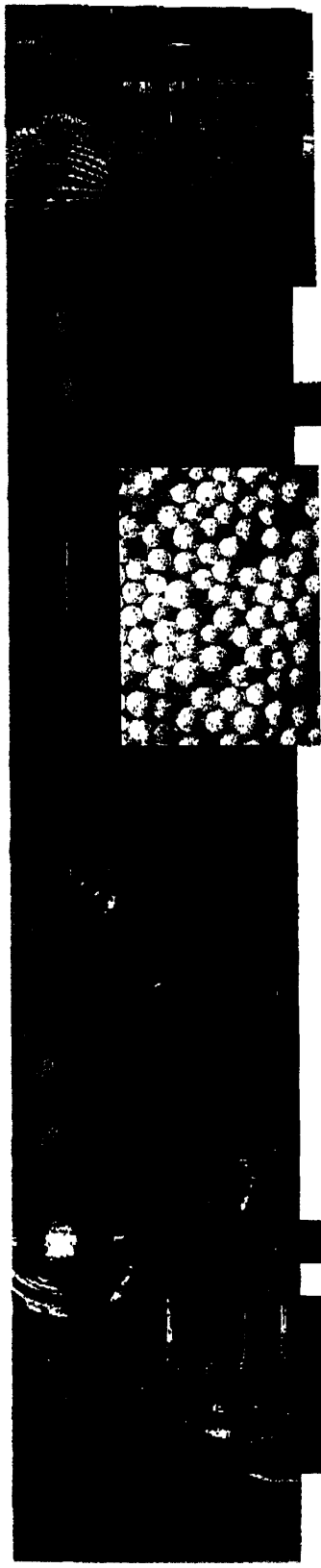
Constant Chlor® Dry Chlorinating Briquettes are available in 50 lb. plastic pails.

Once you've tried our briquettes, you'll know how to achieve the best results consistently.

It's time to call us at **1-800-432-7223** to find out more about Constant Chlor Plus!

Arch Chemicals, Inc.
1955 Lake Park Drive
Suite 250
Smyrna, GA 30080

附件十一 美 USFilter 公司生菌處理廢水系統



BIOSTYR® is a simple and innovative process that carries out effective biological treatment of waste or contaminated water at minimum operating cost.

In over ten years more than 100 reference submerged biofiltration plants have been installed in Eurpoe, Japan and North America. BIOSTYR® is the latest most advanced version of these plants. This process was originally developed for nitrogen elimination in secondary and tertiary treatment and is capable of attaining the highest discharge quality standards.

A highly compact process, BIOSTYR® combines (in a single structure), a biological reactor to degrade pollution and a phase separator to remove the matter transformed by the purification.

The BIOSTYR® process consists of upflow filtration through a submerged and floating fine granular media called BIOSTYRENE.

Air is injected either to the base of the bed or into the media itself. In the latter case, the filter can simultaneously nitrify and denitrify. It is capable of eliminating all biodegradable pollutants: carbon pollution (COD and BOD), suspended solids (SS), ammonia ($N\text{-}NH_4$), and nitrites ($N\text{-}NO_3$).

The bacteria in the effluent attach themselves to the BIOSTYRENE, which simultaneously acts as a filter. The pollution is broken down into cellular material that is retained in the filtering bed by physical retention.

In contrast to other upflow filters (where the media is denser than the water); the head loss in the filter ensures that the effluent to be treated is equally distributed without using; 1) nozzles (that are likely to become clogged) 2) distribution pipework, or 3) a sieve for the effluent before treatment.

Filtration takes place in a direction that compacts the media rather than expanding it, thus enhancing the capture of the suspended material. Periodic counter-current washing eliminates excess biomass and suspended solids that have been filtered, without passing it through the whole bed. Downward flushing evacuates residues via the shortest route out of the bed and in the direction that the particles fall.

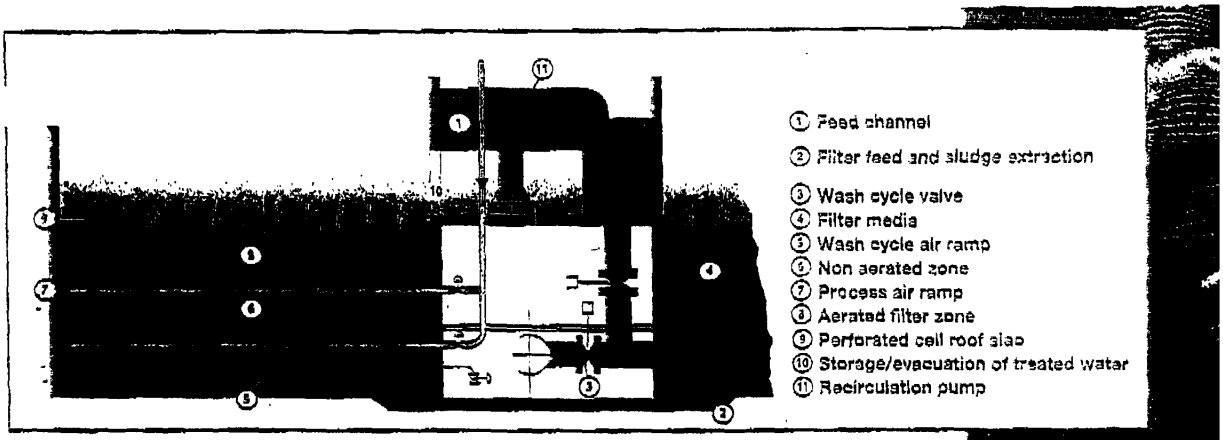
The BIOSTYRENE media is retained by the cell roof that is fitted with nozzles (removable from the top face), which are only in contact with purified water and easily accessible.

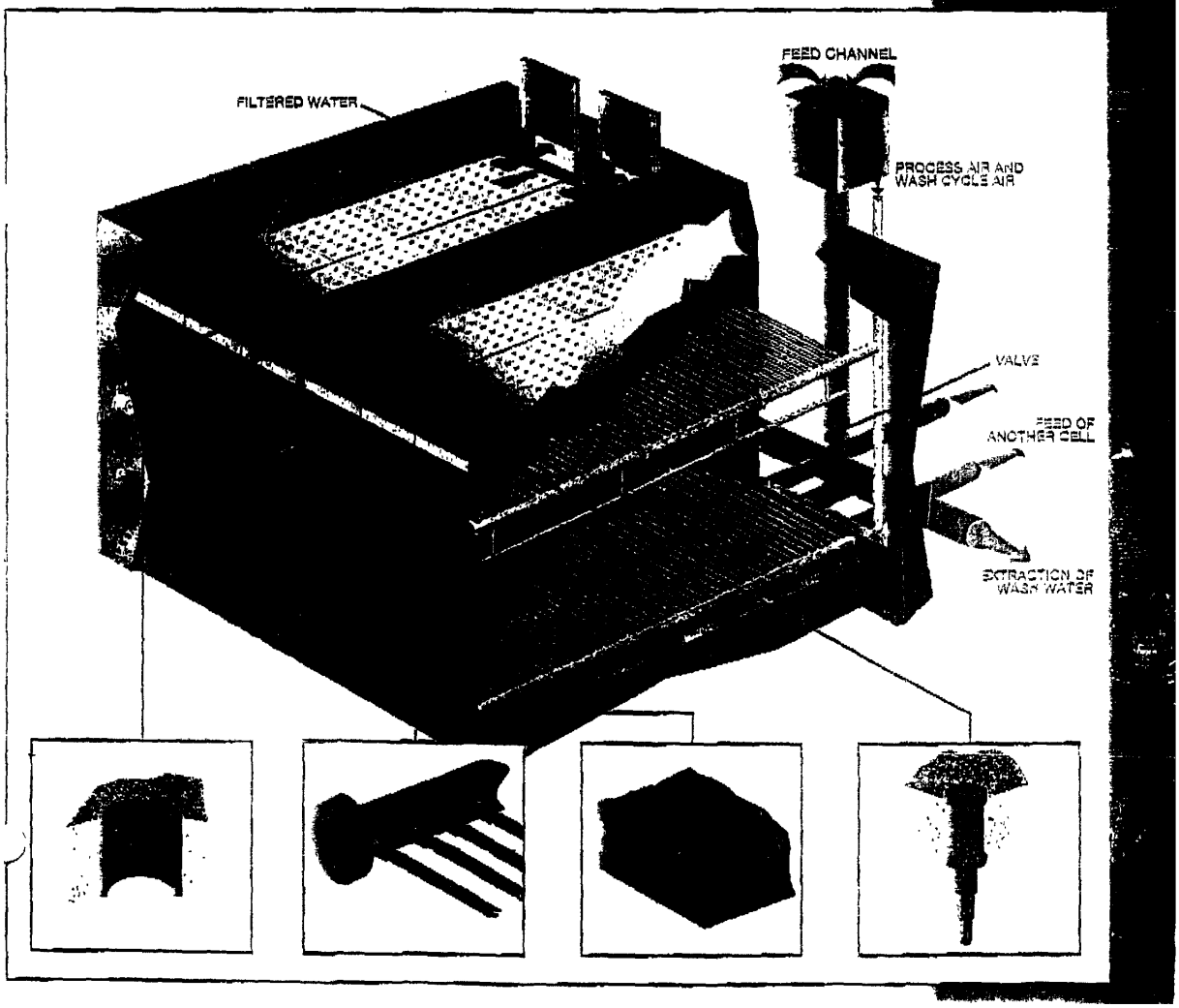
These characteristics are essential to achieving a reliable process protected from any risk of excessive clogging.

BIOSTYRENE media is of small size and uniform shape thus ensuring a high specific surface area, lending itself to;

- Achieving large purification capacities (nitrogen load of >1 kg $N\text{-}NH_4$/m3/d can be eliminated simultaneously with a maximum reduction in COD)
- Achieving high velocities within the media of up to 10m/h in tertiary treatment through the co-current flow of air and water.

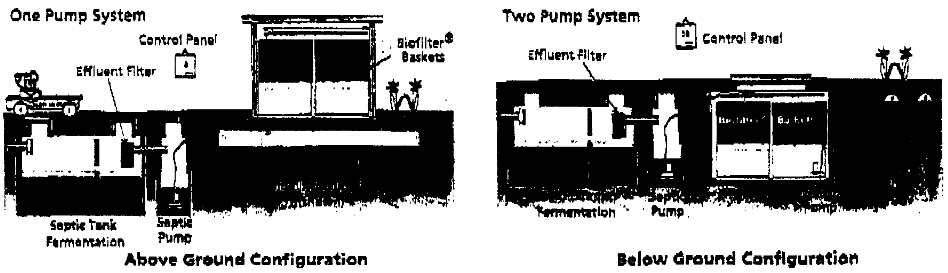
附件十一　美 USFilter 公司生菌處理廢水系統





附件十二 加 Waterloo Biofilter Systems 公司生菌處理廢水系統

How the Waterloo Biofilter Works



Above Ground Configuration

Below Ground Configuration

- The **septic tank** treats raw sewage by fermentation (just like making wine or beer). As such, it is important not to kill the bacteria that carry on this process by using excessive disinfectant in the household.
- An **effluent filter** on the septic tank outlet, pioneered in Ontario by Waterloo Biofilter Systems Inc., screens out large particles ensuring effective treatment by the Biofilter®.
- The **pump chamber** collects septic tank effluent which is sprayed onto the Biofilter®, on a demand or timed basis.
- The **Biofilter®** consists of a patented absorbent filter medium, contained in patented mesh baskets and sized according to your daily water use. The Biofilter® medium houses beneficial microbes that degrade and oxidize organic pollutants, coliform bacteria, ammonium, and other contaminants in septic tank effluent. For a standard 3-4 bedroom house, this unit is 4 ft x 8 ft x 5 ft high. The [illegible] Biofilter® unit may be placed above or below ground.
- **Disposal** of the treated water is to a Waterloo Biofilter Area Bed or Shallow Pressure Trench. The Area Bed and Shallow Pressure Trench disposal methods were pioneered by Waterloo Biofilter Systems Inc. for use in the Canadian climate and are now fully approved in the Province of Ontario.

Proven Applications of the Technology

- Successful sewage treatment at difficult sites
- Immediate reuse of treated wastewater in the home (e.g., Toronto Healthy House)
- Municipal wastewater polishing after alum pretreatment
- Landfill leachate treatment [illegible] disposal
- [illegible] systems
- [illegible]

Installation Cost

The Waterloo Biofilter® treatment and disposal system is installed by certified contractors trained by Waterloo Biofilter Systems Inc. These installers are located across Ontario. The cost to the homeowner of a new, fully installed Waterloo Biofilter® septic system typically ranges between CAN$10,000 and $15,000. The cost depends on the system configuration, size of house, soil type, and access.

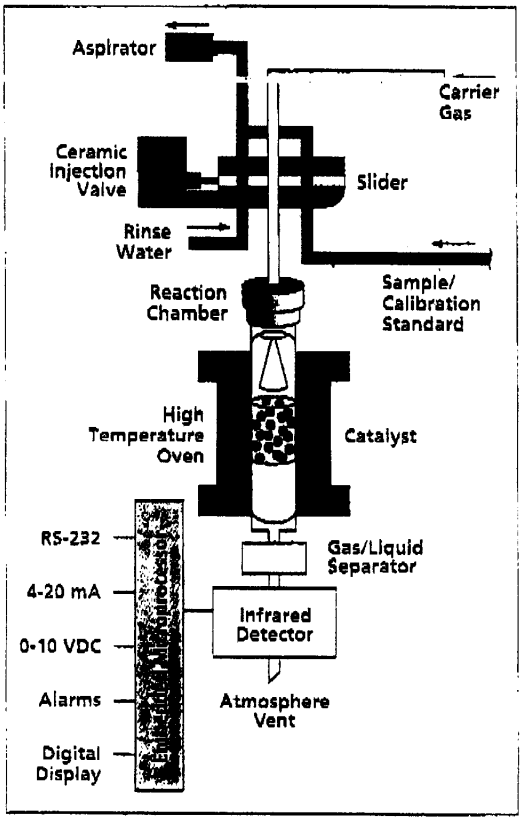
Maintenance

The Waterloo® has few moving parts and is low in maintenance. In Ontario a maintenance contract is required between the homeowner and installer, which covers one or two inspections per year. Routine inspections include: (1) a check of the health of the septic tank, Biofilter®, and disposal bed, (2) cleaning the effluent filter and spray nozzles if needed, and (3) checking the electrical components. In the rare instance where the septic tank has died through misuse (a problem for all types of septic systems) the Biofilter® can be recovered easily. By reducing the use of harsh chemicals or disinfectants in the household and restoring the health of the septic tank (fermentation), the Biofilter® cleans itself up automatically within 1-3 months.

附件十三 美 Ionics 公司線上水質分析儀

Principle of Operation

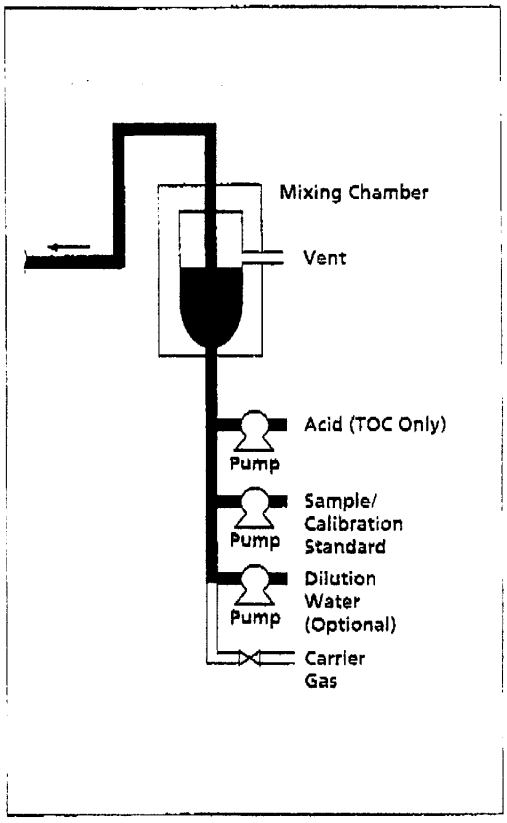
Total Carbon



Total Carbon

A sample from the sample overflow cup is vacuum-aspirated through the injection valve and a precise volume is injected onto a catalyst maintained at 900°C. Under these conditions, all carbon in the sample is quantitatively oxidized to CO_2. The continuously flowing carrier gas transfers the CO_2 into a non-dispersive infrared detector. The concentration of CO_2 measured represents the concentration of total carbon in the sample.

TOC/Dilution



Total Organic Carbon

Measurement of TOC requires the removal of inorganic carbon, such as dissolved CO_2 or carbonates. This is done by acidifying the sample, which converts carbonates to carbon dioxide. The CO_2 is then removed from the sample by sparging with the carrier gas, leaving only organic carbon remaining for analysis. The remaining TOC is analyzed as described for TC.

附件十三 美 Ionics 公司線上水質分析儀

6810 On-line TOC/TC Analyzer Specifications

Analytical Specifications

Analytical Method	Total Carbon (Total Organic Carbon Optional) using High Temperature Catalytic Oxidation with Infrared Detection. ASTM D 5173, EPA 415, "Standard Methods" 5310
Analysis Range	0-10 to 0-2,000 mg/liter (Optional: 0-2 mg/liter to 0-50,000 mg/liter)
Precision	±2% COV (Coefficient of Variation = Standard Deviation/Full Scale) (±5% for sample ranges of 10 mg/liter or less)
Linearity	Correlation coefficient (R^2) of 0.995 or better
Sensitivity	0.1 mg/liter or 0.5% of full scale; whichever is greater
Drift	0% baseline drift with automatic zeroing prior to each analysis
Response Time (Typical)	TC: 2.5 minutes TC with dilution: 5 minutes TOC: 5 minutes TOC with dilution: 6 minutes
Detector	High-sensitivity non-dispersive infrared detector
Environmental Conditions	
Ambient Temperature	1° to 40° C (34° to 104° F)
Ambient Humidity	0 to 95%, non-condensing
Sample Conditions	
Temperature	1° to 60° C (34° to 140° F)
Pressure	0.05 to 0.35 bar (1 to 5 psig)
Sample Flow	50 to 1,000 ml/minute to the sample overflow cup
Suspended Solids Size	200 microns or less (50 microns recommended)
Suspended Solids Conc.	1,000 mg/liter or less
Dissolved Salts	0 to 0.5%; for higher ranges contact Ionics Instruments
Utility Requirements	
Power	Specify voltage: 100/115/230 VAC; 50/60 Hz; 1200 VA
Instrument Air	Instrument grade at 60 psig minimum, 3 CFM (Intermittent)
Carrier Gas	Prepurified nitrogen, CO_2-free air, or oxygen at 120 ml/minute, 30 psig (3.5 bar)
Calibration Standard	Carbon Standard (Concentration per application) (1 liter/week; typical)
Rinse/Dilution Water	De-ionized or distilled (20 liters/week; 25 liters/week with dilution system)
Acid (For TOC Only)	1.0 N* H_2SO_4 (2 liters/week) (*Typical; Concentration dependent on sample alkalinity)
Signal Outputs	
Analog Outputs	0-10 VDC, 4-20 mA isolated
Digital Output	RS-232
Concentration Alarms	Two (2): Dual level with single stream; Single level with dual stream (Solid state relay rated at 1 amp at 24 VDC)
Enclosure	
Rating	IP 44 Standard (Optional IP 65)
Area Classification	Safe area (Refer to hazardous area options)
Mounting	Free-standing strut (Requires securing to floor and/or wall)
Dimensions and Weight	
Dimensions	"T" rack mounting – 72 H x 27 W x 30 D inches (183 x 69x 77 cm) "L" rack or wall mounting – 72 H x 27 Wx 15 D inches (183 x 69 x 39 cm)
Weight	Approximately 230 lbs (105 kg) net; 270 lbs (125 kg) gross shipping within North America; 530 lbs (240 kg) gross shipping weight outside North America.

附件十四 德 Wissenschaftlich-Technische 公司線上水質監視系統

IQ SENSOR NET

WTW

Technical Data

Measuring Principle	Spectral measurement in the UV/VIS range (200 - 750 nm)
Measuring Ranges in Standard Solutions (potassium nitrate, potassium-hydrogenphtalate)	NO_3-N: 0.1 ... 100 mg/l (with 1 mm path length) 0.01 ... 20 mg/l (with 5 mm path length) COD: 0.1 ... 1000 mg/l (with 5 mm path length) TOC: 1 ... 500 mg/l (with 5 mm path length) SAC: 0.1 ... 600 1/m (with 5 mm path length)
Accuracy in Standard Solutions	±3 % of measured value ±0.5 mg/l (with Check algorithm)
Applications	Municipal waste water: inlet, aeration basin, effluent
Materials	Housing: Al Mg Si 1, anodized Windows: sapphire glass
Pressure Resistance	≤ 1 bar
Ambient Conditions	Operating temperature: 0 °C ... +45 °C Storage temperature: -10 °C ... +50 °C
Flow velocity	≤ 3 m/s
pH range	pH 4 ... pH 9
Salt content of medium	< 5000 mg/l (Chloride)
Power Consumption	9 Watt (consumption of cleaning valve included)
Dimensions	650 x 44 mm (length x max. diameter)
Weight	approx. 1.1 kg
Cleaning Pressure	max. 8 bar at the inlet of the cleaning tube

Ordering Information

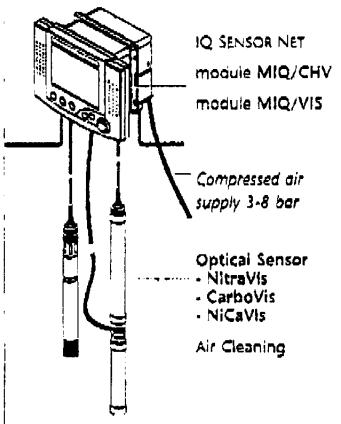
All Sets include:

- Sensor with 15 m cable and compressed air tube
- MIQ/VIS module for connecting the optical sensor
- MIQ/CHV module for controlling the compressed air cleaning

Sets		Order No.
NitraVis 700/1 IQ Set	Optical Nitrate probe with spectral processing of the UV/VIS range; path length 1 mm; robust probe for use in inlet and aeration basin of municipal waste water treatment plants; for use with the IQ Sensor Net System.	481 001
NitraVis 700/5 IQ Set	Optical Nitrate probe with spectral processing of the UV/VIS range; path length 5 mm; robust probe for use in the effluent of municipal waste water treatment plants; for use with the IQ Sensor Net System.	481 003
CarboVis 700/5 IQ Set	Optical COD/TOC/DOC/BOD/SAC probe with spectral processing of the UV/VIS range; path length 5 mm; robust probe for use in inlet and effluent of municipal waste water treatment plants; for use with the IQ Sensor Net System.	481 005
NiCaVis 700/5 IQ Set	Optical probe for measuring Nitrate and COD/TOC/DOC/BOD/SAC with spectral processing of the UV/VIS range; path length 5 mm; robust probe for use in the effluent of municipal waste water treatment plants; for use with the IQ Sensor Net System.	481 007

Options: Nitra/CarboVis sets available with additional TSS measurement

IQ SENSOR NET



Scope of delivery: marked in orange color

Wissenschaftlich-Technische Werkstätten GmbH & Co. KG
Dr.-Karl-Slevogt-Str. 1 · D-82362 Weilheim · Tel. +49(0)881-1830 · Fax +49(0)881-183-420
E-Mail: Info@WTW.com · Internet: http://www.WTW.com

89 951 GB

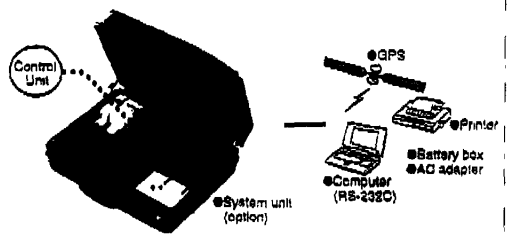
附件十五 美 Horiba 公司水質測量儀器

System enables GPS and numerous other data processing mechanisms

System capabilities can be greatly increased by installing the Global Positioning System (GPS), supplied with unit U-2002. GPS allows measurement of location and time, in addition to water quality, and enables main unit screen display of the obtained data — an indispensable function for maintaining detailed records. With the acquired longitude, latitude and depth data, subject locations can be mapped in 3-D.

GPS functions by processing satellite signals to provide position measurement with pinpoint accuracy. It is widely employed in air and sea navigation, as well as car navigation systems.

The system unit alone is compatible with many I/O interfaces.



COMPACT pH METER

twinpH WATERPROOF pH

Immersion, scoop, and flat measurement.

B-211 single-point pH7 Auto Calibration

B-212 Two point pH7/pH4 Auto Calibration

B-213 Two point pH7/pH4 Auto Calibration

Measurement method	Glass electrode method
Measurement range	pH2 ~ 12
Repeatability	±0.1pH
Power supply	Two 3-volt lithium batteries
Mass	approx. 53g.

water proof

COMPACT CONDUCTIVITY METER

Twin Cond COND SALT

Two measurement methods: drop the sample on the sensor or immerse the sensor in the sample.

B-173

Measurement method		AC bipolar method
Measurement range	Conductivity	0 ~ 19.9mS/cm
	SALT	0 ~ 1.1%
	Temperature	5 ~ 35°C
Repeatability		±1% full scale
Power supply		Two 3-volt lithium batteries
Mass		48g

CARDY Series

CARDY ION

Compact SALT & ION meters

Na^+ Ion meter
C-122 Na^+

K^+ Ion meter
C-131 K^+

NO_3^- Ion meter
C-141 NO_3^-

SALT meter
C-121 SALT

	C-121/122 (Na^+/SALT)	C-131 (K^+)	C-141 (NO_3^-)
Measurement range	0.1%(w/w) ~ 10%(w/w) NaCl 25 ~ 2500ppm Na	39 ~ 3900ppm	62 ~ 6200ppm
Sample amount required	approx. 0.1ml	approx. 0.1ml	approx. 0.1ml
Sample temperature	5 ~ 35°C	5 ~ 35°C	5 ~ 35°C
Liquid junction	Porous macromolecule	Porous macromolecule	Porous macromolecule
Mass	Approx. 90 g		

QWWQ.GuideInfo
Centrifugal Fire Pumps

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[Pumping Equipment for Fire Service] Centrifugal Fire Pumps

Guide Information

Centrifugal fire pumps intended for installation in accordance with NFPA 20 have the following rated capacities: 25, 50, 100, 150, 200, 250, 300, 400, 450, 500, 750, 1000, 1250, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000 gpm or larger. Residential fire pumps intended for installation in accordance with NFPA 13D have rated capacities as indicated in the individual Listings.

Centrifugal fire pumps intended for installation in accordance with NFPA 20 are rated at net head pressures of 40 psi or more. Residential fire pumps are rated at net head pressures as indicated in the individual Listings.

Where a range of rated net head pressure is shown, the manufacturer is in a position to furnish impellers to produce any rated pressure in that range.

The term "Rated Net Pressure" represents the capability of each pump at rated speed and rated capacity.

A Split Case, End Suction, or In-Line pump shall be supplied with water under positive pressure. The "Rated Net Pressure" will be the pressure at the discharge side of the pump minus the pressure at which water is supplied to the pump.

Vertical turbine pumps are capable of lifting water from a source such as a cistern, pond, creek, river, or from other sources. It should be noted that the lift distance is to be measured from the surface to the water source. Where a pump is located above the water surface, the pressure at the discharge side of the pump will be less than the "Rated Net Head Pressure" by an amount, expressed in psi, approximately equivalent to the vertical distance in feet between the center line of the pump discharge and surface of the water source plus loss due to friction in the suction pipe.

10.5 Line Numbering System

All plant piping shall be numbered in accordance with the following line numbering system:

Line Description

Example HC 1 140 - A24A - 2" H

Line Legend (2/3 Digits) — HC

Area Code (1 Digit) — 1

Line Serial No. — 140
(3 Digits for existing lines)
(4 Digits for new lines)
(for Furnace lines suffix K and L may be used)

Piping Class — A24A

Line Size — 2"

Insulation Type — H

Line\Legend

Process Fluid

HC	Hydrocarbons

Water Lines

BFW	Boiler Feedwater
CWS	Cooling Water Supply
CWR	Cooling Water Return
CWT	Cooling Water Tempered
DW	Drinking Water
DMW	Demineralised Water
FW	Fire Water
RW	Raw Water
PW	Process Water
QW	Quench Water
SW	Service Water

TW	Treated Water

Steam Condensate Lines

DS	Dilution Steam
SL	Steam S3.5
SLM	Steam S12
SM	Steam S40
SH	Steam S105
SCL	Steam Condensate Low
SCM	Steam Condensate Medium
SCH	Steam Condensate High

Air Lines

CA	Combustion Air
IA	Instrument Air
PA	Plant Air

Relief & Blowdown

BD	Blowdown
RV	Relief System

Sewers

CS	Chemical Sewer
OWS	Oily Water Sewer
SS	Storm Sewer

Others

FO	Fuel Oil
FG	Fuel Gas
GN	Nitrogen
RE	Refrigeration Ethylene
RP	Refrigeration Propylene
AC	Acid Lines
KA	Caustic Lines
CF	Chemical Feed
NH	Neutralised Amine
QO	Quench Oil
PO	Pan Oil
FLO	Flushing Oil

Online Certifications Directory

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Company Name	Category Name	Link to File
BERMAD CONTROL VALVES	Fire Pump Relief Valves	***QXZQ.EX6009***
CLA-VAL CO	Fire Pump Relief Valves	***QXZQ.EX2855***
WEIR FLOWAY INC, DBA FLOWAY PUMPS	Centrifugal Fire Pumps, Split Case	***QXJY.EX6068***
WEIR FLOWAY INC, DBA FLOWAY PUMPS	Centrifugal Fire Pumps, Vertical Turbine	***QXXW.EX3013***
WEIR FLOWAY INC, DBA FLOWAY PUMPS	Centrifugal Fire Pumps, Vertical Turbine Certified for Canada	***QXXW7.EX3013***
WESTATES TRUCK EQUIPMENT CORP	Automotive Fire Apparatus	***AZYF.EX4732***

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Notice of Disclaimer ☐Questions?

CA Fire Pump Manuf.

STONE & WEBSTER	J.O./W.O. No:	11811
	CLIENT:	Formosa Petrochemicals Corporation
PROJECT SPECIFICATION	PROJECT:	OL-1 Expansion Project
No: 11811-PS-U-106	LOCATION:	Mai-Liao, Taiwan

ATTACHMENT 1 - VENDORS INFORMATION PACKAGE

A4 DOCUMENTATION

A4.1 The Vendor will forward a noise test report containing the results of the noise test to the purchaser within two weeks of completion of the test.

A4.2 Information in the report will include the following as a minimum;

- all measurements taken, including background noise levels before and after the test;
- details of any calculations and corrections made to measured noise levels;
- details of any tonal or impulsive characteristics;
- dimensioned sketch of equipment and surrounding test area showing measurement locations and any other nearby equipment items;
- operating conditions of equipment under test;
- details of noise control features fitted for duration of test;
- description of any other factors which may have affected the data presented.

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Company Name	Category Name	Link to File
AURORA PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, In-line Certified for Canada	***QXCZ7.EX4017***
AURORA PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Split Case	***QXJY.EX2638***
AURORA PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Split Case Certified for Canada	***QXJY7.EX2638***
AURORA PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Vertical Turbine	***QXXW.EX1593***
AURORA PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Vertical Turbine Certified for Canada	***QXXW7.EX1593***
BERMAD CONTROL VALVES	Fire Pump Relief Valves	***QXZQ.EX6009***
BOISE MOBILE EQUIPMENT INC	Automotive Fire Apparatus	***AZYF.EX4679***
CATERPILLAR INC ENGINE DIV	Internal Combustion Engines for Driving Centrifugal Fire Pumps	***QYLU.EX1716***
CENTRAL STATES FIRE APPARATUS INC	Automotive Fire Apparatus	***AZYF.EX3626***
CLA-VAL CO	Fire Pump Relief Valves	***QXZQ.EX2855***
CLARKE FIRE PROTECTION PRODUCTS INC	Internal Combustion Engines for Driving Centrifugal Fire Pumps	***QYLU.EX3342***
CLARKE FIRE PROTECTION PRODUCTS INC	Internal Combustion Engines for Driving Centrifugal Fire Pumps Certified for Canada	***QYLU7.EX3342***
CLARKE FIRE PROTECTION PRODUCTS INC	Internal Combustion Engines with Controllers for Driving Centrifugal Fire Pumps	***QYST.EX3342***
CRIMSON FIRE INC	Automotive Fire Apparatus	***AZYF.EX4691***
CRIMSON FIRE INC	Automotive Fire Apparatus	***AZYF.EX3114***

STONE & WEBSTER	J.O./W.O. No:	11811
	CLIENT:	Formosa Petrochemicals Corporation
PROJECT SPECIFICATION	PROJECT:	OL-1 Expansion Project
No: 11811-PS-U-106	LOCATION:	Mai-Liao, Taiwan

ATTACHMENT 1 - VENDORS INFORMATION PACKAGE

A5 GUARANTEE

A5.1 The Vendor shall guarantee the equipment noise levels for all new, replacement and modified equipment specified in the purchase order. Where requested, a noise guarantee acceptance test shall be performed by the Vendor.

A5.2 The Vendor shall confirm the dates of witness test a minimum of seven days prior to the event so that a Purchaser representative may be present. The Vendor shall perform the test in accordance with his Quality Plan and this specification.

A5.3 The requirement for the noise test may be waived by the Purchaser where:

a. The supply of equipment is similar to that recently purchased.

b. Acceptable and certified equipment noise test data is furnished by the Vendor.

A5.4 Any remedial work performed either by Purchaser or Vendor as a result of Vendor's failure to meet the guaranteed noise level shall be at the expense of the Vendor. Equipment shall be made available for remedial work at a time designated by the Purchaser.

STONE & WEBSTER	J.O./W.O. No:	11811
	CLIENT:	Formosa Petrochemicals Corporation
PROJECT SPECIFICATION	PROJECT:	OL-1 Expansion Project
No: 11811-PS-U-106	LOCATION:	Mai-Liao, Taiwan

ATTACHMENT 1 - VENDORS INFORMATION PACKAGE

A6 GENERAL NOISE CONTROL DESIGN GUIDANCE

A6.1 Acoustic Enclosures

Enclosures can be designed to provide large insertion losses across a wide frequency spectrum, although the lower the frequency, the more 'massive' the walls will need to be for a given insertion loss.

Enclosures can be small (i.e. closing fitting) or large, allowing personnel access for inspection/maintenance.

The overall performance of an acoustic enclosure is achieved by a combination of sound transmission loss and sound absorption, though the transmission loss is by far the more important. The most common form of construction is outer steel sheet (typically 14-16 swg thickness) lined internally with mineral wool or fiberglass layers of typically 80 kgm-3 density and 50 mm thickness. For high insertion loss requirements, the thickness of both the steel sheets and absorptive layer may need to be increased. The inner surface of the absorptive material should be faced with a perforated or expanded metal sheet plus a thin impervious membrane of polyurethane. This thin membrane should be a maximum of 25 microns thick and held in a non-taut state between the absorptive layer and the perforated or expanded metal sheet. This membrane will prevent a build-up of hazardous vapours within the absorptive layer and will protect the absorbent materials from oil spills, etc. The perforated sheet should typically be 16-20 swg thickness with a minimum open area of 20% and a maximum hole diameter of 3 mm. If expanded metal sheet is used the open area can be 70 – 90% since these materials retain considerably greater strength than perforates, even with a large open area.

For small enclosures, all panels may be permanently fixed to the framework and the complete enclosure made removable for inspection. Alternatively, selected panels may be made to be easily removed for inspection of important parts, e.g. couplings. For large enclosures allowing access for personnel, the enclosure should be considered permanent, and be constructed so that panels are demountable for major equipment removal or overhaul only. Enclosure panels that are permanentiy fixed are more likely to maintain a good acoustic performance than removable panels, which are more likely to warp and to have sealing strips damaged.

Particular attention should be paid to sealing panels at corners, around doors and around all pipework which penetrates the enclosure panels.

The framework should not be rigidly attached to a skid or floor without vibration isolation, unless the enclosed equipment is mounted on a separate pedestal or skid, which is not attached to the same structure as the enclosure. Failure to observe this detail may result in structureborne noise being transmitted through the floor and exciting the enclosure panels, which will then radiate sound. The vibration isolation system used will depend on the mass, stiffness etc, of the enclosure and the frequency of the exciting force. For large enclosures, a large number of spring isolators may be required, with a natural frequency at least 30% less than the lowest exciting frequency. For small, light enclosures, a resilient strip along the base of the enclosure perimeter may be sufficient.

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Company Name	Category Name	Link to File
CUMMINS ENGINE CO INC	Internal Combustion Engines, For Driving Centrifugal Fire Pumps	***QYLU.EX1675***
CUTLER-HAMMER INC, SUB OF EATON CORP	Pump Controllers, Fire	***QYZS.EX820***
DINGEE MACHINE CO	Automotive Fire Apparatus	***AZYF.EX4210***
E J MURPHY CO **MURPHY FABRICATIONS INC CO**	Automotive Fire Apparatus	***AZYF.EX2419***
E-ONE NEW YORK	Automotive Fire Apparatus	***AZYF.EX2603***
EDWARDS MFG INC	Internal Combustion Engines for Driving Centrifugal Fire Pumps	***QYLU.EX4525***
EDWARDS MFG INC	Internal Combustion Engines with Controllers for Driving Centrifugal Fire Pumps	***QYST.EX4525***
ELITE POWER PRODUCTS	Automotive Fire Apparatus	***AZYF.EX6556***
EMERGENCY ONE INC, SUB OF FEDERAL SIGNAL CORP	Automotive Fire Apparatus	***AZYF.EX4480***
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, In-Line	***QXCZ.EX4612***
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, In-line Certified for Canada	***QXCZ7.EX4612***
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Split Case	***QXJY.EX743***
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Split Case Certified for Canada	***QXJY7.EX743***
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Vertical Turbine	***QXXW.EX1345***

Doors in large enclosures should be self closing and be easily opened from the inside in case of emergency. The door should be of a similar construction to the fixed panels, and above all, should seal well. If windows are required, they should be double-glazed (unless very small) so that the overall performance is not compromised.

Besides the acoustic considerations, an enclosure must comply with all other process and safety aspects, including ventilation and fire protection and detection. The installation of an enclosure around certain items of equipment may change the hazard classification, creating a potentially dangerous area.

Ventilation may be required for cooling and for the removal of a potential gas hazard. However, a ventilation system may have two adverse effects on the external acoustic environment:

1. The cooling fan itself may generate sufficient noise to cause a problem.

2. The 'hole' in the enclosure wall for ducting, will provide an easy airborne path for the noise of the enclosed machine, effectively short-circuiting the enclosure.

Both of these effects can be avoided by careful design of the ventilation system, but will often necessitate the use of silencers.

Where only a small noise reduction is required, lightweight and partially open enclosures can be employed, thus overcoming weight and hazardous gas objections.

A6.2 Acoustic Cladding

Cladding is an alternative to enclosure for equipment requiring only a moderate degree of noise reduction and where only limited space is available. The principle is similar to that of acoustic pipe lagging, in that a combination of an outer massive wrap and flexible isolating layer is used. It is suitable where only part treatment of an operating unit is required, or where enclosure is difficult (e.g. compressor and pump bodies), although thermal insulation effects and access restriction have to be considered. (Generally acoustic cladding systems are not readily remountable after removal).

The insulating layer should have a minimum thickness of 50 mm and be of non-rigid mineral wool or glass fiber of minimum density 80 kgm-3. The insulating layer is applied directly to the equipment surface although in some instances it is necessary to incorporate a vapour barrier between the equipment surface and the insulating layer. The outer massive casing should be sufficiently flexible to be formed around the equipment surface on top of the insulating layer. For small items of equipment, the maximum thickness is governed by the curvature required but should not be less than 1 mm (18 swg) pregalvanised or stainless steel.

Cladding can also be applied to fan casings and rectangular ductwork to prevent panel resonances and noise breakout.

A6.3 Acoustic Lagging

Acoustic pipework lagging is similar to thermal lagging, consisting of an outer dense impervious wrap isolated from the pipework by a layer of flexible mineral wool or glass fiber. Indeed an acoustic pipe lagging system will often satisfy the requirements for thermal insulation but the reverse is generally not true, since acoustic pipe lagging requires far greater attention to detail on installation then thermal lagging.

If the specified insulating layer for thermal insulation is rigid, e.g. calcium silicate, this will not be adequate for most acoustic applications.

The density of the insulating layer will vary depending on the required acoustic performance. As a general guide a 50 mm thick layer of glass fiber or mineral wool of typical density 65-80 kgm-3 will be adequate for small reductions at high frequencies. For greater insertion losses the density of the insulator should be increased up to about 140 kgm-3 and for high insertion losses over a wider frequency range, the thickness should also be increased. Generally, a 100 mm thick layer of dense insulation will be sufficient for almost all noisy pipe applications.

The outer wrap serves to protect the insulating layer and provides attenuation by transmission loss. For most attenuation requirements, a surface weight of 5 kgm-2 will be adequate – for steel, this is equivalent to 22 swg. For high attenuation requirements, a surface weight of 10 kgm-2 may be required (18 swg).

The most important factors governing the performance of the lagging are the quality of the sealing and the thoroughness of the insulation over flanges, junctions, etc. None of the acoustic benefits of increasing insulation thickness and density or outer wrap surface weight will be achieved if these flanking paths are present. The outer wrap should not make contact with the pipe since this will provide mechanical coupling, i.e. a structureborne path, by which vibrations of the pipe will be transmitted to the outer wrap and be re-radiated as sound.

For high performance, pipe flanges and blanked ends should be insulated in a similar manner to the main sections of the piping, that is they should be covered with an insulating layer and outer wrap of similar materials to the pipe.

Terminations of acoustic lagging should be sealed with 'end caps' and should be isolated from the pipe wall by the use of resilient sealing strips. The material of the sealing strips should be suitable for the intended operating temperatures and be resistant to oil and water.

In order to achieve the best acoustic performance all circumferential and longitudinal laps should be completely covered and sealed to remain airtight.

All control valves and pipework that are acoustically lagged should also be vibration isolated from the supporting steelwork. If vibration isolation is not incorporated, noise may be radiated by the pipe supports, which are rigidly fixed to the pipe. Vibration isolating pipe hangers or springs should incorporate a resilient material, since a spring will provide isolation at mid and low frequencies, but will transmit high frequency sound. Pipe hangers should typically have a minimum static deflection of 6 mm. All breaks in the outer wrap (e.g. for pipe hangers and supports) should be sealed using a flexible sealant.

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CUMMINS ENGINE CO INC	Internal Combustion Engines, For Driving Centrifugal Fire Pumps	QYLU.EX1675
CUTLER-HAMMER INC, SUB OF EATON CORP	Pump Controllers, Fire	QYZS.EX820
DINGEE MACHINE CO	Automotive Fire Apparatus	AZYF.EX4210
E J MURPHY CO MURPHY FABRICATIONS INC CO	Automotive Fire Apparatus	AZYF.EX2419
E-ONE NEW YORK	Automotive Fire Apparatus	AZYF.EX2603
EDWARDS MFG INC	Internal Combustion Engines for Driving Centrifugal Fire Pumps	QYLU.EX4525
EDWARDS MFG INC	Internal Combustion Engines with Controllers for Driving Centrifugal Fire Pumps	QYST.EX4525
ELITE POWER PRODUCTS	Automotive Fire Apparatus	AZYF.EX6556
EMERGENCY ONE INC, SUB OF FEDERAL SIGNAL CORP	Automotive Fire Apparatus	AZYF.EX4480
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, In-Line	QXCZ.EX4612
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, In-line Certified for Canada	QXCZ7.EX4612
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Split Case	QXJY.EX743
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Split Case Certified for Canada	QXJY7.EX743
FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Vertical Turbine	QXXW.EX1345

Acoustic lagging provides the best attenuation for high frequency sound, such as that produced by centrifugal compressors, screw compressors, gaseous control valves etc., where attenuation of up to 25 dB(A) can be achieved. This level of performance would only be expected from an insulation layer of 100 mm thickness and fairly high density and a good standard of installation. For a 50 mm thick insulation layer of medium density and outer wrap of steel an attenuation of 15-20 dB(A) may be expected.

The performance of acoustic lagging falls off sharply below about 1 kHz – if the source noise spectrum peaks in the 500 Hz octave band, the overall attenuation with a 50 mm insulation layer would fall to less than 10 dB(A). For lower frequency attenuation, the insulation layer must be increased in thickness. The maximum attenuation expected from lagging a pipe radiating sound in the mid-frequency range would be 10-15 dB(A).

Noise is attenuated along a pipe with distance but the rate of fall-off is dependent upon many factors, including pipe diameter, wall thickness and pipe material, the type of fluid, its molecular weight, pressure, temperature, and the piping configuration, i.e. number of bends, junctions and other discontinuities. Thus each application may be different, necessitating a high attenuation over a relatively short distance, or a low attenuation over a considerable length of piping.

A6.4 Screens and Barriers

Screens or barriers have limited applications in shielding the receiver from a noise source. They do not provide significant energy dissipation and whilst providing useful reduction in noise level at some locations they can in certain cases increase the noise levels at other locations by reflection. Their use is not normally recommended if other forms of noise control are available. If they are employed, great care is needed in their design and siting.

The performance of a barrier is frequency dependent, in that low frequency sound is diffracted around a barrier where the wavelength of the sound is equal to or greater than the dimensions of the barrier. For broad-band noise this gives rise to a practical limit of 10-15 dB(A) for a barrier attenuation. Transmission of sound through a barrier is not therefore a significant factor, since the transmission loss of the barrier material is likely to be considerably greater than the attenuation achieved by the screening effect.

Improved attenuation may be achieved by 'wrapping' the barrier around the source to form a partial enclosure, and lining the internal face of the barrier with absorbent material. Partial enclosure of machines, particularly portable equipment and sources having directional sound radiation characteristics, can be afforded by demountable partitions or 'acoustic curtaining' which can be drawn round the machine to reduce noise levels in adjoining areas. In enclosed areas barriers are usually rendered ineffective by multiple reflections off the containing walls. Some limited benefits can be obtained, where only small attenuation's are required, by using acoustically lined screens and acoustically treating those walls in the immediate vicinity from which the most important first reflections would be received.

FAIRBANKS MORSE PUMP, MEMBER OF PENTAIR PUMP GROUP	Centrifugal Fire Pumps, Vertical Turbine Certified for Canada	***QXXW7.EX1345***

A6.5 Silencers - General

Silencers are employed in a wide range of applications and can be considered as sections of pipe or duct, which have been acoustically treated or shaped to reduce noise transmission in the contained medium.

There are two basic types of silencer, reactive and absorptive. Reactive silencers rely on sound reflections from abrupt changes in shape and cavity resonance effects. As such they provide attenuation over a narrow band of frequencies and, by changing the geometry, can be tuned to a given frequency. This is particularly useful where the noise source has a dominant frequency characteristic, or for low frequency applications.

Absorptive silencers rely upon the dissipation of acoustic energy by materials such as glass fiber or mineral wool. Such silencers provide attenuation over a wide range of mid and high frequencies with the performance depending on thickness of absorbent, length of silencer and width of airway.

For broadband applications a combination of reactive and absorptive sections may be employed.

A6.6 Electric Motor Silencers

The variation in electric motor designs invariably necessitates the design of motor silencers on an individual basis. Many suppliers offer low-noise motors, which incorporate acoustic treatment. The acoustic performance of a motor silencer is often, limited by the allowable pressure drop through it.

Motor silencers are essentially, short sections of lined duct, fitted over the air inlet and air outlet. The inlet duct is usually narrow and lined with 25 mm or 50 mm of mineral wool or similar absorptive material, although the narrower the airway, the greater will be the pressure loss through the silencer. For large motors, splitters can be incorporated into the silencer to increase the area of lined duct.

The design of the outlet silencer is more dependent on the actual motor design, since outlet configurations vary considerably from motor to motor. For motors where the air is directed over 'fins' from slots behind the fan cowling, a close-fitting, absorptively-lined cowl should be fitted over the 'fins'. In motors that are cooled by the air being ducted through tubes, the cooling air and noise emanate from an annulus of holes at the rear of the motor body. An annular shaped silencer must therefore be designed, which will fit closely to the end of the motor.

The materials for both inlet and outlet silencers are usually galvanised steel with an internal layer of absorbent, faced with a perforated sheet if necessary.

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FERRARA FIRE APPARATUS INC	Automotive Fire Apparatus	***AZYF.EX4475***
FIRE MASTER FIRE APPARATUS INC	Automotive Fire Apparatus	***AZYF.EX2735***
FIRE RESEARCH CORP	Flowmeters For Fire Pumps	***HDKU.EX4542***
FORSTNER FIRE APPARATUS	Automotive Fire Apparatus	***AZYF.EX2474***
FOUR GUYS STAINLESS TANK & EQUIPMENT INC	Automotive Fire Apparatus	***AZYF.EX4032***
GENERAL SAFETY EQUIPMENT CORP	Automotive Fire Apparatus	***AZYF.EX4524***
GFE MFG INC	Fire Pump Flow Testing Equipment	***HNJR.EX4673***
GOWANS-KNIGHT CO INC	Automotive Fire Apparatus	***AZYF.EX4672***
H&W APPARATAS REPAIR INC, DBA H&W EMERGENCY VEHICLE SERVICE	Automotive Fire Apparatus	***AZYF.EX4370***
HME INC	Automotive Fire Apparatus	***AZYF.EX6571***
HUBBELL INDUSTRIAL CONTROLS INC	Pump Controllers, Fire	***QYZS.EX1243***
HUBBELL INDUSTRIAL CONTROLS INC	Transfer Switches for Use in Fire Pump Motor Circuits	***XNVE.E66646***
ITT A-C FIRE PUMP SYSTEMS	Centrifugal Fire Pumps - End Suction	***QWZU.EX3786***
ITT A-C FIRE PUMP SYSTEMS	Centrifugal Fire Pumps, In-Line	***QXCZ.EX4374***
ITT A-C FIRE PUMP SYSTEMS	Centrifugal Fire Pumps, In-line Certified for Canada	***QXCZ7.EX4374***

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	CLIENT:	Formosa Petrochemicals Corporation
PROJECT SPECIFICATION	PROJECT:	OL-1 Expansion Project
No: 11811-PS-U-106	LOCATION:	Mai-Liao, Taiwan

Wherever possible, for new designs, motors and silencers should be purchased as a package. Where this is not possible, the motor manufacturer should be asked to supply details of the allowable pressure drop through the silencer. For critical pressure drop applications, it is recommended that the advice of a silencer supplier is sought, since data on designing silencers to meet specified pressure drops are mainly empirical, not calculated. In an extreme case this could save the considerable expense of a burnt-out motor, caused by fitting a silencer with too great a pressure drop.

The allowable pressure drop through a motor silencer is usually the determining factor in obtaining the maximum sound attenuation. Where more than 10-15 dB(A) overall reduction is required a full acoustic enclosure is usually necessary.

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ITT A-C FIRE PUMP SYSTEMS	Centrifugal Fire Pumps, Vertical Turbine Certified for Canada	QXXW7.EX3780
ITT A-C FIRE PUMP SYSTEMS	Centrifugal Fire Pumps--Vertical Turbine	QXXW.EX3780
ITT A-C PUMP, UNIT OF ITT CORP	Centrifugal Fire Pumps, Split Case	QXJY.EX284
ITT BELL & GOSSETT AC FIRE PUMP SYSTEMS	Centrifugal Fire Pumps, Vertical Turbine	QXXW.EX6074
ITT BELL & GOSSETT AC FIRE PUMP SYSTEMS	Centrifugal Fire Pumps, Vertical Turbine Certified for Canada	QXXW7.EX6074
ITT INDUSTRIES GOULDS PUMPS	Centrifugal Fire Pumps, Vertical Turbine	QXXW.EX6143
ITT INDUSTRIES GOULDS PUMPS	Centrifugal Fire Pumps, Vertical Turbine Certified for Canada	QXXW7.EX6143
JOHNSTON PUMP CO	Centrifugal Fire Pumps--Vertical Turbine	QXXW.EX2127
JOSLYN CLARK CONTROLS INC	Battery Chargers for Use with Internal Combustion Engine Driving Centrifugal Fire Pumps - Component	QWIR2.EX4485
JOSLYN CLARK CONTROLS INC	Magnetic - Component	NLDX2.E6591
JOSLYN CLARK CONTROLS INC	Pump Controllers, Fire	QYZS.EX386
JOSLYN CLARK CONTROLS INC	Pump Controllers, Fire Certified For Canada	QYZS7.EX386
JOSLYN CLARK CONTROLS INC	Pump Controllers, Fire, Over 600 V	QZGR.EX5075
JOSLYN CLARK CONTROLS INC	Pump Controllers, Fire, Over 600 V Certified For Canada	QZGR7.EX5075
JOSLYN CLARK CONTROLS INC	Pump Controllers, Fire, Residential	QZKE.EX4168

ATTACHMENT 6

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VENDOR'S DOCUMENTATION INDEX AND SCHEDULE

VENDOR:	PO NO:
CONTACT:	ITEM NO:
TELEPHONE:	VENDOR'S REF:
	TELEX NO:

DISTRIBUTION SCHEDULE AND ACTION CLASS

S&W DOC CODE	PROJECT DOC NO	VENDOR DOCUMENT	REV	DOCUMENT DESCRIPTION OR TITLE	ISSUE DATE PLANNED / ACTUAL	REMARKS	PROJECT	INSTRUMENTATION	ELECTRICAL	MACHINERY	SPECIAL EQUIPMENT	FURNACES	VESSELS	HEAT EXCHANGERS	CIVIL/UNDERGROUND	PIPING	STRESS & SUPPORTS	METALLURGY	STRUCTURAL/PAU	SITE	QUALITY ASSURANCE	SYSTEM PROCESS	ARCHITECTURAL	INSPECT/PROCUREMENT	CLIENT

TITLE OF EQUIPMENT
REQUISITION NO:
S&W DOC CODE:

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ONAN CORP, DBA CUMMINS POWER GENERATION	Transfer Switches for Use in Fire Pump Motor Circuits	***XNVE.E44433***
PACO PUMPS INC	Centrifugal Fire Pumps--Split Case	***QXJY.EX4183***
PATTERSON PUMP CO, SUB OF THE GORMAN-RUPP CO	Centrifugal Fire Pumps - End Suction	***QWZU.EX3908***
PATTERSON PUMP CO, SUB OF THE GORMAN-RUPP CO	Centrifugal Fire Pumps, End Suction Certified for Canada	***QWZU7.EX3908***
PATTERSON PUMP CO, SUB OF THE GORMAN-RUPP CO	Centrifugal Fire Pumps, In-Line	***QXCZ.EX3883***
PATTERSON PUMP CO, SUB OF THE GORMAN-RUPP CO	Centrifugal Fire Pumps, In-line Certified for Canada	***QXCZ7.EX3883***
PATTERSON PUMP CO, SUB OF THE GORMAN-RUPP CO	Centrifugal Fire Pumps, Split Case	***QXJY.EX1717***
PATTERSON PUMP CO, SUB OF THE GORMAN-RUPP CO	Centrifugal Fire Pumps, Split Case Certified for Canada	***QXJY7.EX1717***
PATTERSON PUMP CO, SUB OF THE GORMAN-RUPP CO	Centrifugal Fire Pumps, Vertical Turbine	***QXXW.EX3709***
PATTERSON PUMP CO, SUB OF THE GORMAN-RUPP CO	Centrifugal Fire Pumps, Vertical Turbine Certified for Canada	***QXXW7.EX3709***
PATTERSON PUMP CO, SUB OF THE GORMAN-RUPP CO	Internal Combustion Engines with Controllers for Driving Centrifugal Fire Pumps	***QYST.EX6271***
PEERLESS PUMP/STERLING FLUID SYSTEMS (USA) INC	Centrifugal Fire Pumps - End Suction	***QWZU.EX4869***
PEERLESS PUMP/STERLING FLUID SYSTEMS (USA) INC	Centrifugal Fire Pumps, End Suction Certified for Canada	***QWZU7.EX4869***
PEERLESS PUMP/STERLING FLUID SYSTEMS (USA) INC	Centrifugal Fire Pumps, In-Line	***QXCZ.EX3732***

RECOMMENDED OPERATING SPARE PARTS FOR 24 MONTHS

DESCRIPTION OF PART NOTE EACH ITEM TO BE TAGGED WITH CONTRACTOR'S PART NO FROM COL 4a	SPARE PART NUMBER	MATERIAL	CONTRACTOR'S CROSS SECTION DRAWING NUMBER	CONTRACTOR'S PART REF	SPARES RECOMMENDED BY CONTRACTOR	OWNER'S REQUIREMENTS	INITIAL UNIT PRICE PER PART (OR SET)	TOTAL PRICE	REMARKS (see Note 3) NB INDICATE CHANGEABILITY
1	2	3	4	4a	5	6	7	8	9

NOTES:

1 All columns to be completed by Contractor except Owner's requirements
2 Contractor to note Original Manufacturer and Identification Number where applicable
3 Contractor shall enter, in the appropriate squares, the number of components per item fitted in each piece of equipment.
4 Operating spares shall be packed and shipped with the equipment.
5 After purchase order Contractor to include Spare Part Drawing(s)/sketch(es) as applicable.

NO	REVISION	DATE
7		
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EQUIPMENT

CONTRACTOR

EQUIPMENT REQUISITION NO

ROSP

PEERLESS PUMP/STERLING FLUID SYSTEMS (USA) INC	Centrifugal Fire Pumps, Split Case	***QXJY.EX570***

COMMISSIONING SPARE PARTS LIST

DESCRIPTION OF PART NOTE EACH ITEM T BE TAGGED WITH CONTRACTOR'S PART NO FROM COL 4a	SPARE PART NUMBER	MATERIAL	CONTRACTOR'S CROSS SECTION DRAWING NUMBER	CONTRACTOR'S PART REF	SPARES RECOMMENDED BY CONTRACTOR	INITIAL UNIT PRICE PER PART (OR SET)	TOTAL PRICE	REMARKS (see Note 3)
1	2	3	4	4a	5	6	7	8

NOTES:

1. All columns to be completed by Contractor except Owner's requirements
2. Contractor to note Original Manufacturer and Identification Number where applicable.
3. Contractor shall enter, in the appropriate squares, the number of components per item fitted in each place of equipment.
4. Operating spares shall be packed and shipped with the equipment

NO.	REVISION	DATE
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PEERLESS PUMP/STERLING FLUID SYSTEMS (USA) INC	Centrifugal Fire Pumps, Vertical Turbine	QXXW.EX1572
PIERCE MFG INC	Automotive Fire Apparatus	AZYF.EX4346
R D MURRAY INC	Automotive Fire Apparatus	AZYF.EX4264
REBERLAND EQUIPMENT INC	Automotive Fire Apparatus	AZYF.EX4636
REDDY-BUFFALOES PUMP INC	Centrifugal Fire Pumps, End Suction	QWZU.EX3676
REDDY-BUFFALOES PUMP INC	Centrifugal Fire Pumps, Split Case	QXJY.EX3560
REDDY-BUFFALOES PUMP INC	Centrifugal Fire Pumps, Vertical Turbine	QXXW.EX3884
REDDY-BUFFALOES PUMP INC	Centrifugal Fire Pumps-In-Line	QXCZ.EX3878
REDDY-BUFFALOES PUMP INC	Flowmeters For Fire Pumps	HDKU.EX5105
RENEWED PERFORMANCE INC	Automotive Fire Apparatus	AZYF.EX4149
RUSSELECTRIC INC	Transfer Switches for Use in Fire Pump Motor Circuits	XNVE.E42157
S & S FIRE APPARATUS CO	Automotive Fire Apparatus	AZYF.EX4068
SEAGRAVE FIRE APPARATUS L L C	Automotive Fire Apparatus	AZYF.EX5225
SEAGRAVE FIRE APPARATUS L L C	Automotive Fire Apparatus	AZYF.EX2410

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LUBRICATION SCHEDULE

POINT TO BE LUBRICATED	OIL OR GREASE	LUBRICANT SPECIFICATION	EQUIVALENT LUBRICANT	QUANTITY			REMARKS
				INITIAL FILL	CONSUMPTION RATE	RECOMMENDED 12 MONTHS HOLDING	

EQUIPMENT

VENDOR

MODEL

ITEM NO

EQUIPMENT REQUISITION NO

LUBRICANT SCHEDULE NO

Online Certifications Directory

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Company Name	Category Name	Link to File
U S ELECTRICAL MOTORS, DIV OF EMERSON ELECTRIC CO	Fire Pump Motors	***QXZF.EX5189***
U S TANKER-FIRE APPARATUS INC	Automotive Fire Apparatus	***AZYF.EX4663***
VAL-FAB INC	Automotive Fire Apparatus	***AZYF.EX6317***
VAL-MATIC VALVE & MFG CORP	Air Release Valves For Fire Pumps	***QWBS.EX5148***
VALVE & PRIMER CORP	Air Release Valves For Fire Pumps	***QWBS.EX3227***
W S DARLEY & CO	Automotive Fire Apparatus	***AZYF.EX4726***
WATTS AUTOMATIC CONTROL VALVE	Fire Pump Relief Valves	***QXZQ.EX3467***
WATTS REGULATOR CO	Fire Pump Relief Valves	***QXZQ.EX4047***
WDM INC	Centrifugal Fire Pumps--Split Case	***QXJY.EX4938***
WEIR FLOWAY INC, DBA FLOWAY PUMPS	Centrifugal Fire Pumps, Split Case	***QXJY.EX6068***
WEIR FLOWAY INC, DBA FLOWAY PUMPS	Centrifugal Fire Pumps, Vertical Turbine	***QXXW.EX3013***
WEIR FLOWAY INC, DBA FLOWAY PUMPS	Centrifugal Fire Pumps, Vertical Turbine Certified for Canada	***QXXW7.EX3013***
WESTATES TRUCK EQUIPMENT CORP	Automotive Fire Apparatus	***AZYF.EX4732***
WESTERN STATES FIRE APPARATUS INC	Automotive Fire Apparatus	***AZYF.EX2465***
WESTEX WELDING CO	Automotive Fire Apparatus	***AZYF.EX4351***

SPECIAL TOOLS FOR INSTALLATION AND MAINTENANCE

DESCRIPTION OF PART NOTE EACH ITEM TO BE TAGGED WITH CONTRACTOR'S PART NO FROM COL 3	CONTRACTOR'S CROSS SECTION DRAWING NUMBER	CONTRACTOR'S PART REF	TOTAL PRICE	REMARKS (see Note 3)
	2	3	4	5

NOTES:
1. All columns to be completed by Contractor.
2. Contractor to note Original Manufacturer and Identification Number where applicable.
3. Tools shall be packed and shipped with the equipment

No.	REVISION	DATE
7		
6		
5		
4		
3		
2		
1		

CONTRACTOR

EQUIPMENT REQUISITION NO

CSP

CHAPTER 3
FIRE PUMP INSTALLATION SYSTEMS

FIRE PUMPS

Before ordering a fire pump, consult Factory Mutual Research regarding size, type of driver, suction supplies and location. Proposals for fire pump installations, including plans showing location and piping connections, should be sent to FM Global for review before the order is placed. Give the manufacturer complete data, including rated capacity, net head and suction head. Contracts for pump installations or changes should be let subsequent to acceptance of plans and subject to satisfactory field tests by FM Global.

The pump manufacturer or his authorized representative is responsible for furnishing a complete unit consisting of pump, driver and necessary accessories, all according to FM Global's standards.

Satisfactory performance in an operating test after installation should be guaranteed. A new fire pump installation is not acceptable until FM Global has witnessed a satisfactory field acceptance test. This will include a test of endurance of the pump and reliability of the power supply.

Exact horsepower requirements for each pump must be determined by a shop test on the specific pump. Approximate horsepower requirements at rated pump conditions are as follows:

Rated Capacity, gal/min (dm^3/min)	*Rated Net Head, psi (kPa)*	*Approximate Power Required, hp (kW)*
500 (1895)	100 (690)	50-60 (37-45)
750 (2840)	100 (690)	60-75 (45-56)
1000 (3785)	100 (690)	75-100 (56-75)
1500 (5680)	100 (690)	100-125 (75-93)
2000 (7570)	100 (690)	125-150 (93-112)
2500 (9465)	100 (690)	150-200 (112-149)

In the listings below, rated net head represents the amount of pressure boost obtainable from a pump of a given type and impeller size when operating at rated speed.

The rated net head range indicates that impellers of various diameters are obtainable for the given type of pump.

Although not recommended for installations where suction is normally taken under lift, Approved pumps have been tested for proper operation under negative suction conditions up to 15 ft (5 m) at 150% of rated capacity.

CENTRIFUGAL FIRE PUMPS, Horizontal Split-Case Type

Factory Mutual Research Approved horizontal split-case type centrifugal fire pumps are relatively simple to operate and repair. These pumps have a two-part casing divided in a horizontal plane through the shaft centerline. They are well suited to fire protection service where a water supply is obtainable under a positive head.

Horizontal Mounted

Armstrong Darling Inc 23 Bertrand Ave Toronto Ontario Canada M1L 2P3

Armstrong Pumps Limited, Pear Tree Rd, Stanway, Colchester, Essex UK C03 5JX

Rated Capacity, gal/min (dm^3/min)	*Rated Net Head, psi (kPa)*	*Rated Speed, r/min*	*Type Designation*	*Suction Inlet, dia., in.*	*Discharge Outlet, dia., in.*	*Stage*
500 (1895)	41-63 (285-435)	1780	5x4x12HF	5	4	1
500 (1895)	41-91 (285-625)	2100	5x4x12HF	5	4	1
500 (1895)	53-116 (365-800)	2350	5x4x12HF	5	4	1
500 (1895)	41-92 (285-635)	2600	5x4-10F	5	4	1
500 (1895)	48-107 (330-740)	2800	5x4-10F	5	4	1
500 (1895)	44-120 (305-830)	2945	5x4-10F	5	4	1
500 (1895)	46-124 (315-855)	3000	5x4-10F	5	4	1
500 (1895)	66-175 (455-1205)	3560	5x4-10F	5	4	1
500 (1895)	75-135 (515-930)	1760	BP-F	5	4	1
750 (2840)	45-68 (310-470)	1780	6x5x12HF	6	5	1
750 (2840)	56-115 (386-793)	2350	6x5x12MF	6	5	1
750 (2840)	72-143 (496-986)	2600	6x5x12MF	6	5	1
750 (2840)	83-126 (572-869)	2350	6x5x12HF	6	5	1
750 (2840)	85-167 (586-1151)	2800	6x5x12MF	6	5	1
750 (2840)	95-125 (655-860)	1760	BP-F	5	4	1
750 (2840)	95-186 (655-1282)	2945	6x5x12MF	6	5	1
750 (2840)	60 (415)	1775	BE-F	6	5	1
750 (2840)	54-92 (370-635)	2600	6x5-10F	6	5	1
750 (2840)	63-107 (435-740)	2800	6x5-10F	6	5	1
750 (2840)	71-117 (490-805)	2945	6x5-10F	6	5	1
750 (2840)	74-123 (510-850)	3000	6x5-10F	6	5	1
750 (2840)	77-170 (530-1170)	3560	5x4-10F	5	4	1
750 (2840)	80-112 (550-770)	2945	5x4-10F	5	4	1
750 (2840)	83-116 (570-800)	3000	5x4-10F	5	4	1
750 (2840)	84-107 (580-740)	2350	5x4-12HF	5	4	1
750 (2840)	110-175 (760-1025)	3560	6x5-10F	6	5	1
750 (2840)	145-278 (1000-1917)	3560	6x5x12MF	6	5	1
1000 (3785)	100 (690)	1770	BN-F	6	5	1
1000 (3785)	51-96 (350-660)	1780	6x5-15F	6	5	1
1000 (3785)	60-93 (415-640)	2600	8x6-10LF	8	6	1
1000 (3785)	63-125 (435-860)	2945	8x6-10LF	8	6	1
1000 (3785)	65-129 (450-890)	3000	8x6-10LF	8	6	1
1000 (3785)	75-137 (515-945)	2100	6x5-15F	6	5	1
1000 (3785)	77-120 (531-827)	2350	6x5x12HF	6	5	1

Rated Capacity, gal/min (dm³/min)	Rated Net Head, psi (kPa)	Rated Speed, r/min	Type Designation	Suction Inlet, dia., in.	Discharge Outlet, dia., in.	Stage
3500 (13 250)	95-206 (655-1420)	1900	PC10E*	12	10	1
3500 (13 250)	141-176 (970-1215)	1780	BR12C†	16	12	1
4000 (15 140)	139-174 (960-1200)	1780	BR12C†	16	12	1
4000 (15 140)	66-108 (455-745)	1480	BR12D†	16	12	1
4000 (15 140)	94-118 (650-815)	1480	BR12C†	16	12	1
4000 (15 140)	131-199 (903-1372)	1490	BS12A†	16	12	1
4000 (15 140)	102-161 (705-1110)	1780	BR12D†	16	12	1
4000 (15 140)	78-112 (540-770)	1480	PA12F*	14	12	1
4000 (15 140)	112-161 (770-1110)	1760	PA12F*	14	12	1
4000 (15 140)	100-117 (690-805)	1775	PC10D*	12	10	1
4500 (17 035)	76-109 (525-750)	1480	PA12F*	14	12	1
4500 (17 035)	91-116 (625-800)	1480	BR12C†	16	12	1
4500 (17 035)	126-196 (869-1351)	1490	BS12A†	16	12	1
4500 (17 035)	136-172 (940-1185)	1780	BR12C†	16	12	1
4500 (17 035)	109-160 (750-1105)	1760	PA12F*	14	12	1
4500 (17 035)	63-105 (435-725)	1480	BR12D†	16	12	1
4500 (17 035)	93-114 (640-785)	1775	PC10D*	12	10	1
4500 (17 035)	99-158 (685-1090)	1780	BR12D†	16	12	1
5000 (18 925)	122-193 (841-1331)	1490	BS12A†	16	12	1
5000 (18 925)	108-157 (730-1080)	1760	PA12F*	14	12	1
5000 (18 925)	95-154 (640-1065)	1780	BR12D†	16	12	1

*When requested, SPP can furnish pumps designed for applications where the suction pressures exceed 75 psi (515 kPa). These pumps are designated by the addition of the letter "H" after the type designation.
**These pumps are available for operation at any speed within the range shown. The intended operating speed should be specified when the pump is ordered.
†These designations have (FM) following the designation number

WDM Pumps de Mexico, SA de CV Niquel No. 9214, Cd Industrial Mitras Garcia, Neuvo Leon, Mexico 66000

Rated Capacity, gal/min (dm³/min)	Rated Net Head, psi (kPa)	Rated Speed, r/min	Type Designation	Suction Inlet, dia., in.	Discharge Outlet, dia., in.	Stage
250 (946)	94-151 (645-1041)	1750	HD040317 CIBF	4	3	1
500 (1893)	123-193 (848-1331)	3550	HR40611B CIBF	6	4	1
750 (2839)	93-143 (641-986)	1750	HD060417 CIBF	6	4	1
750 (2839)	108-197 (745-1358)	1750	HD080620 CIBF	8	6	1
1000 (3785)	78-135 (538-931)	1750	HD080617 CIBF	8	6	1
1000 (3785)	106-195 (731-1345)	1750	HD080620 CIBF	8	6	1
1250 (4732)	76-131 (524-903)	1750	HD080617 CIBF	8	6	1
1250 (4732)	103-195 (710-1338)	1750	HD080620 CIBF	8	6	1
1500 (5678)	71-125 (490-862)	1750	HD100817 CIBF	8	6	1
1500 (5678)	100-190 (690-1310)	1750	HD080620 CIBF	8	6	1
1500 (5678)	110-186 (758-1282)	1750	HD100820 CIBF	10	8	1
1500 (5678)	100-153 (690-1055)	1750	HN081218A CIBF	12	8	1
2000 (7570)	87-128 (600-880)	1750	HD100817 CIBF	10	8	1
2000 (7570)	100-181 (600-880)	1750	HD100820 CIBF	10	8	1
2000 (7570)	97-150 (669-1034)	1750	HN081218A CIBF	12	8	1
2500 (9463)	92-146 (634-1007)	1750	HN081218A CIBF	12	8	1

Vertical Mounted

Aurora Pump, A Member of the Pentair Pump Group 800 Airport Rd North Aurora IL 60542

Rated Capacity, gal/min (dm³/min)	Rated Net Head, psi (kPa)	Rated Speed, r/min	Type Designation	Suction Inlet, dia., in.	Discharge Outlet, dia., in.	Stage
250 (945)	40-100 (275-690)	3560	3-483-10	4	3	1
500 (1895)	40-55 (275-380)	1770	4-483-11A	5	4	1
500 (1895)	50-150 (345-1035)	3560	3-483-10	4	3	1
500 (1895)	60-80 (415-550)	1770	4-483-15	5	4	1
750 (2840)	40-50 (275-345)	1770	4-483-11A	5	4	1
750 (2840)	65-205 (450-1415)	3560	4-483-11C	5	4	1
750 (2840)	71-97 (490-670)	1770	4-483-15	5	4	1
750 (2840)	50-70 (345-485)	1770	5-483-15	6	5	1
1000 (3785)	50-94 (345-650)	1770	5-483-15	6	5	1
1000 (3785)	90-128 (620-885)	1770	5-483-17	6	5	1
1000 (3785)	120-200 (825-1380)	3550	5-483-11B	6	5	1
1000 (3785)	90-160 (620-1105)	3550	5-483-11C	6	5	1
1000 (3785)	40-52 (275-360)	1770	6-483-11	8	6	1
1250 (4730)	43-53 (295-365)	1770	8-483-12	10	8	1
1250 (4730)	55-96 (380-660)	1770	6-483-15	8	6	1
1250 (4730)	100-138 (690-950)	1770	6-483-18B	8	6	1
1250 (4730)	87-168 (600-1160)	1770	6-483-20	8	6	1
1500 (5680)	50-93 (345-640)	1770	6-483-15	8	6	1
1500 (5680)	80-165 (550-1140)	1770	6-483-20	8	6	1
1500 (5680)	40-50 (275-345)	1770	8-483-12	10	8	1
1500 (5680)	95-134 (655-925)	1770	6-483-18B	8	6	1
2000 (7570)	100-140 (690-965)	1770	6-483-18C	8	6	1
2000 (7570)	120-152 (825-1050)	1770	6-483-20	8	6	1
2000 (7570)	51-130 (350-895)	1770	8-483-17B	10	8	1
2500 (9465)	75-130 (515-895)	1770	8-483-17B	10	8	1

When requested, Aurora can furnish pumps designed for application where suction pressures exceed 40 psi (275 kPa). These pumps are designated by the addition of the letter "H" after the type designation.

Patterson Pump Co, Sub Gorman-Rupp Co Box 790 Toccoa GA 30577

Rated Capacity, gal/min (dm³/min)	Rated Net Head, psi (kPa)	Rated Speed, r/min	Type Designation	Suction Inlet, dia., in.	Discharge Outlet, dia., in.	Stage
500 (1895)	40-100 (275-690)	1760	4x3 MEV	4	3	1
500 (1895)	40-122 (275-840)	3550	5x3 MACV	5	3	1
500 (1895)	41-66 (285-450)	1450	6x5x17 SSCV	6	5	1

Rated Capacity, gal/min (dm³/min)	Rated Net Head, psi (kPa)	Rated Speed, r/min	Type Desig-nation	Suction Inlet, dia., in.	Dis-charge Outlet, dia., in.	Stage
500 (1895)	43 -68 (295-470)	1475	6x5x17 SSCV	6	5	1
500 (1895)	53-91 (365-625)	1450	6x5x17 SSCV	6	5	1
500 (1895)	55-93 (370-640)	1475	6x5x17 SSCV	6	5	1
500 (1895)	61-95 (420-655)	1750	6x5x17 SSCV	6	5	1
500 (1895)	63-97 (435-685)	1775	6x5x17 SSCV	6	5	1
500 (1895)	77-142 (530-970)	1750	6x5x17 SSCV	6	5	1
500 (1895)	80-146 (550-100)	1775	6x5x17 SSCV	6	5	1
500 (1895)	100-182 (690-1255)	3550	6x5 MAAV	6	5	1
750 (2840)	40-61 (275-420)	1450	6x5x17 SSCV	6	5	1
750 (2840)	40-64 (275-440)	1475	6x5x17 SSCV	6	5	1
750 (2840)	40-70 (275-485)	1760	5x4 MV	5	4	1
750 (2840)	48-82 (325-570)	1450	6x5x17 SSCV	6	5	1
750 (2840)	50-87 (345-600)	1475	6x5x17 SSCV	6	5	1
750 (2840)	58-92 (400-635)	1750	6x5x17 SSCV	6	5	1
750 (2840)	59-95 (405-655)	1775	6x5x17 SSCV	6	5	1
750 (2840)	70-125 (485-860)	1760	6x5 MV	6	5	1
750 (2840)	73-134 (505-925)	1750	6x5x17 SSCV	6	5	1
750 (2840)	63-123 (435-850)	3550	5x4 MACV	6	4	1
750 (2840)	75-140 (515-950)	1775	6x5x17 SSCV	6	5	1
750 (2840)	100-180 (690-1240)	3550	6x5 MAAV	6	5	1
1000 (3785)	51-125 (350-860)	1760	6x5 MV	6	5	1
1000 (3785)	53-86 (360-595)	1750	6x5x17 SSCV	6	5	1
1000 (3785)	55-90 (370-620)	1775	6x5x17 SSCV	6	5	1
1000 (3785)	66-125 (450-850)	1750	6x5x17 SSCV	6	5	1
1000 (3785)	68-129 (470-890)	1775	6x5x17 SSCV	6	5	1
1000 (3785)	112-165 (770-1140)	3550	6x5 MAAV	6	5	1
1500 (5680)	40-100 (275-690)	1760	8x6 MIV	8	6	1

Note: Standard construction includes ASA 125 suction and discharge flanges. For ASA 250 discharge flanges, suffix H is added to type designations.

Reddy-Buffaloes Pump Inc 1 Dixie Dr Box 557 Baxley GA 31513

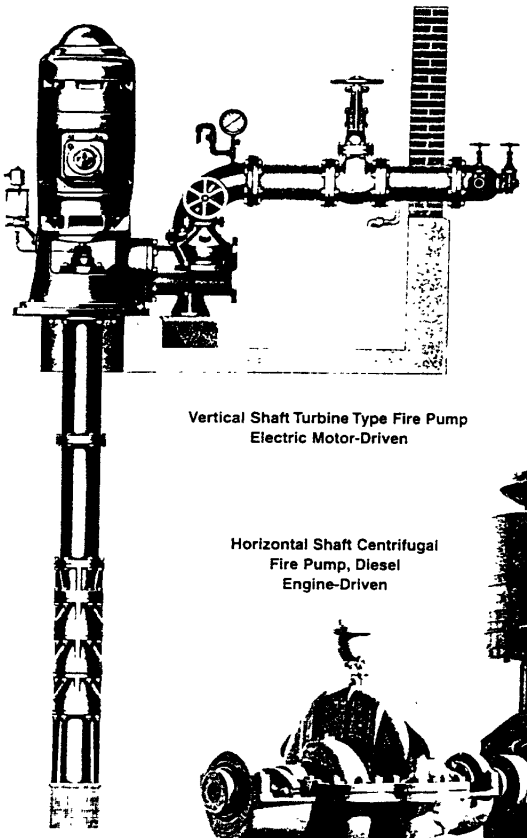
500 (1895)	40-56 (275-385)	1760	6x6 DFV	6	6	1
500 (1895)	40-67 (275-460)	1775	8x8 DFV	8	8	1
500 (1895)	40-143 (275-985)	3000	6x6 DFV	6	6	1
500 (1895)	49-173 (340-1195)	3300	6x6 DFV	6	6	1
500 (1895)	57-185 (395-1275)	3540	6x6 DFV	6	6	1
500 (1895)	58-217 (400-1495)	3570	6x6 DFV	6	6	1
750 (2840)	40-53 (275-365)	1760	6x6 DFV	6	6	1
750 (2840)	40-65 (275-450)	1775	8x8 DFV	8	8	1
750 (2840)	40-135 (275-930)	3000	6x6 DFV	6	6	1
750 (2840)	49-165 (340-1140)	3300	6x6 DFV	6	6	1
750 (2840)	57-180 (395-1240)	3540	6x6 DFV	6	6	1
750 (2840)	58-210 (400-1450)	3570	6x6 DFV	6	6	1
750 (2840)	105-245 (725-1690)	3495	8x8 DFV	8	8	1
750 (2840)	115-260 (795-1795)	3580	8x8 DFV	8	8	1
1000 (3785)	40-60 (275-415)	1775	8x8 DFV	8	8	1
1000 (3785)	46-122 (315-840)	3000	6x6 DFV	6	6	1
1000 (3785)	54-125 (370-860)	1775	8X8 LDFV	8	8	1
1000 (3785)	75-155 (515-1070)	3300	6x6 DFV	6	6	1
1000 (3785)	60-169 (415-1165)	3540	6x6 DFV	6	6	1
1000 (3785)	62-200 (430-1380)	3570	6x6 DFV	6	6	1
1000 (3785)	105-238 (725-1640)	3495	8x8 DFV	8	8	1
1000 (3785)	115-266 (790-1835)	3580	8x8 DFV	8	8	1
1250 (4730)	43-61 (295-420)	1775	8x8 DFV	8	8	1
1250 (4730)	41-128 (285-885)	1780	8x8 LDFV	8	8	1
1250 (4730)	52-117 (360-805)	1775	8X8 LDFV	8	8	1
1250 (4730)	100-230 (690-1585)	3495	8x8 DFV	8	8	1
1250 (4730)	105-188 (725-1295)	3565	6x6 DFV	6	6	1
1250 (4730)	113-260 (780-1795)	3580	8x8 DFV	8	8	1
1500 (5680)	40-126 (275-870)	1780	8x8 LDFV	8	8	1
1500 (5680)	48-110 (330-760)	1775	8X8 LDFV	8	8	1
1500 (5680)	97-223 (670-1540)	3495	8x8 DFV	8	8	1
1500 (5680)	105-253 (725-1745)	3580	8x8 DFV	8	8	1
2000 (7570)	43-115 (295-795)	1780	8x8 LDFV	8	8	1
2000 (7570)	154-229 (1060-1580)	3580	8x8 DFV	8	8	1

CENTRIFUGAL FIRE PUMPS, Horizontal End-Suction Type

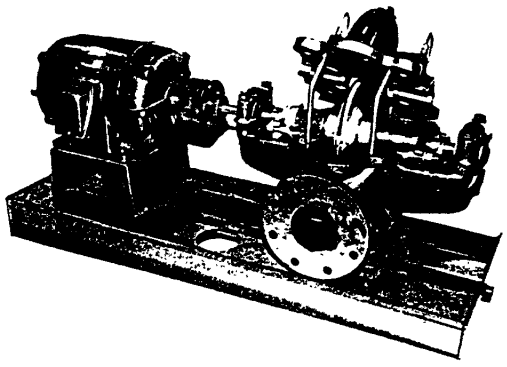
Factory Mutual Research Approved horizontal end-suction fire pumps must be of the "back-pullout" design and be driven through a spacer coupling. That is, it must be possible to replace the rotating assembly of an installed pump without disturbing suction and discharge piping or the driver. These pumps feature a horizontal suction connection opposite the driver end and a vertical, centerline discharge connection.

Armstrong Darling Inc 23 Bertrand Ave Toronto Ontario Canada M1L 2P3
Armstrong Pumps Limited, Pear Tree Rd, Stanway, Colchester, Essex UK C03 5JX

Rated Capacity, gal/min (dm³/min)	Rated Net Head, psi (kPa)	Rated Speed, r/min	Type Desig-nation	Suction Inlet, dia., in.	Dis-charge Outlet, dia., in.	Stage
300 (1135)	70-135 (485-930)	2350	4x3-13FM	4	3	1
300 (1135)	88-167 (605-1150)	2600	4x3-13FM	4	3	1
300 (1135)	114-212 (785-1460)	2945	4x3-13FM	4	3	1

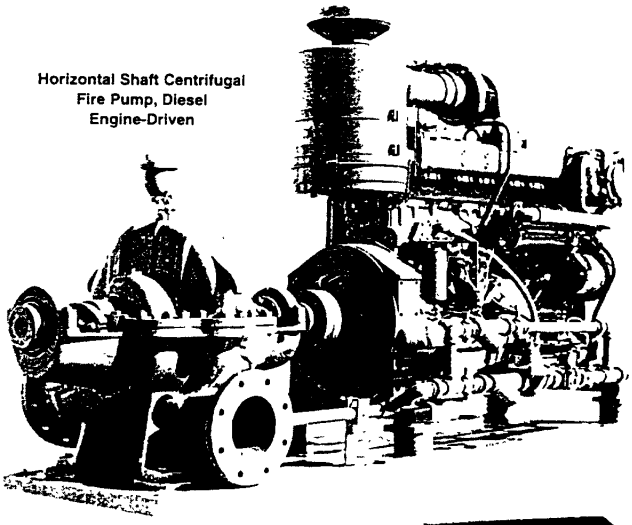


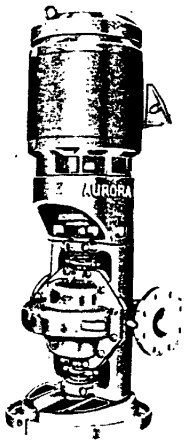
Vertical Shaft Turbine Type Fire Pump
Electric Motor-Driven



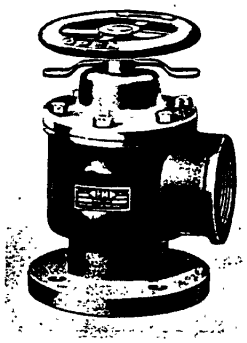
Horizontal Shaft Centrifugal Fire Pump, Electric Motor-Driven

Horizontal Shaft Centrifugal
Fire Pump, Diesel
Engine-Driven

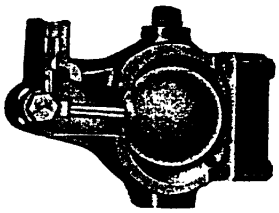




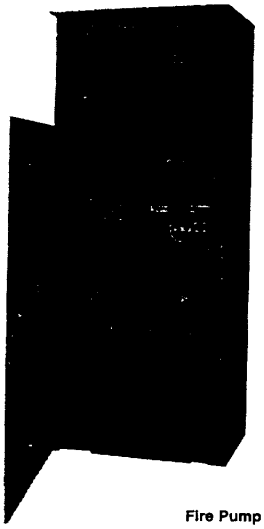
Vertical-Mounted Centrifugal Fire Pump
Electric Motor-Driven

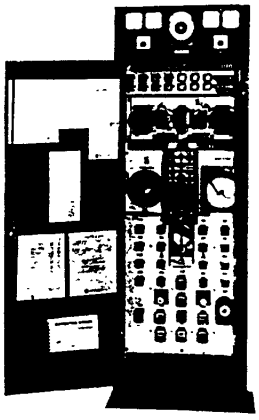


Water Relief Valve



Air Release Valve





Fire Pump Controllers

Rated Capacity, gal/min (dm³/min)	*Rated Net Head, psi (kPa)*	*Rated Speed, r/min*	*Type Designation*	*Suction Inlet, dia., in.*	*Discharge Outlet, dia., in.*	*Stage*
Sterling Fluid Systems Ltd, Theale Cross, Pincents Lane, Calcot, Reading, Berkshire RG31 7SP England						
200 (755)	51-78 (352-538)	3500	AV03N	4	3	1
200 (755)	52-81 (359-558)	2950	KP08V	4	3	1
200 (755)	55-101 (379-696)	2950	KP06D	4	3	1
200 (755)	70-112 (483-772)	2600	KP05E	2½	2	1
200 (755)	74-115 (510-793)	3500	KP08V	4	3	1
200 (755)	93-148 (641-1020)	2950	KP05E	2½	2	1
250 (945)	50-77 (345-531)	3500	AV03N	4	3	1
250 (945)	51-78 (352-538)	2950	KP08V	4	3	1
250 (945)	55-101 (379-696)	2950	KP06D	4	3	1
250 (945)	73-112 (503-772)	3500	KP08V	4	3	1
250 (945)	88-142 (607-979)	2950	KP05E	2½	2	1
250 (945)	90-108 (621-745)	2600	KP05E	2½	2	1
300 (1135)	48-75 (331-517)	3500	AV03N	4	3	1
300 (1135)	49-76 (338-524)	2950	KP08V	4	3	1
300 (1135)	52-100 (358-690)	2950	KP06D	4	3	1
300 (1135)	55-92 (380-635)	2350	KP08E	4	3	1
300 (1135)	69-114 (475-785)	2600	KP08E	4	3	1
300 (1135)	71-110 (490-758)	3500	KP08V	4	3	1
300 (1135)	80-132 (550-910)	2800	KP08E	4	3	1
300 (1135)	89-147 (615-1015)	2950	KP08E	4	3	1
300 (1135)	122-135 (841-930)	2950	KP05E	2½	2	1
400 (1515)	43-70 (296-483)	3500	AV03N	4	3	1
400 (1515)	46-71 (317-490)	2950	KP08V	4	3	1
400 (1515)	52-91 (360-630)	2350	KP08E	4	3	1
400 (1515)	62 (425)	1450	KP12Y	6	5	1
400 (1515)	62-97 (428-669)	2950	KP06D	4	3	1
400 (1515)	66-112 (455-770)	2600	KP08E	4	3	1
400 (1515)	67 (460)	1500	KP12Y	6	5	1
400 (1515)	68-104 (469-717)	3500	KP08V	4	3	1
400 (1515)	77-130 (530-890)	2800	KP08E	4	3	1
400 (1515)	86-145 (595-1000)	2950	KP08E	4	3	1
400 (1515)	96 (660)	1800	KP12Y	6	5	1
400 (1515)	107 (740)	1900	KP12Y	6	5	1
450 (1705)	40-67 (276-462)	3500	AV03N	4	3	1
450 (1705)	44-68 (303-469)	2950	KP08V	4	3	1
450 (1705)	50-88 (345-605)	2350	KP08E	4	3	1
450 (1705)	63-111 (435-765)	2600	KP08E	4	3	1
450 (1705)	67-100 (462-690)	3500	KP08V	4	3	1
450 (1705)	75-129 (515-890)	2800	KP08E	4	3	1
450 (1705)	84-144 (580-995)	2950	KP08E	4	3	1
500 (1895)	86 (595)	2350	KP08E	4	3	1
500 (1895)	61-108 (420-745)	2600	KP08E	4	3	1
500 (1895)	64-97 (441-669)	3500	KP08V	4	3	1
500 (1895)	72-127 (495-875)	2800	KP08E	4	3	1
500 (1895)	82-142 (565-980)	2950	KP08E	4	3	1
500 (1895)	85-149 (586-1027)	2600	KP15Y	8	6	1
500 (1895)	98-138 (676-952)	2800	KP15Y	8	6	1
500 (1895)	108-154 (745-1062)	2950	KP15Y	8	6	1
500 (1895)	112-159 (772-1096)	3000	KP15Y	8	6	1
750 (2840)	83-148 (572-1020)	2600	KP15Y	8	6	1
750 (2840)	97-137 (669-945)	2800	KP15Y	8	6	1
750 (2840)	107-153 (738-1055)	2950	KP15Y	8	6	1
750 (2840)	111-158 (765-1089)	3000	KP15Y	8	6	1
1000 (3785)	79-145 (545-1000)	2600	KP15Y	8	6	1
1000 (3785)	95-136 (655-938)	2800	KP15Y	8	6	1
1000 (3785)	106-152 (731-1048)	2950	KP15Y	8	6	1
1000 (3785)	110-157 (758-1083)	3000	KP15Y	8	6	1
1250 (4730)	74-142 (510-979)	2600	KP15Y	8	6	1
1250 (4730)	89-132 (614-910)	2800	KP15Y	8	6	1
1250 (4730)	101-149 (696-1027)	2950	KP15Y	8	6	1
1250 (4730)	105-154 (724-1062)	3000	KP15Y	8	6	1
1500 (5680)	80-127 (552-876)	2800	KP15Y	8	6	1
1500 (5680)	95-144 (655-993)	2950	KP15Y	8	6	1
1500 (5680)	99-150 (683-1034)	3000	KP15Y	8	6	1

All the listed pumps have (FM) following the Designation number.

CENTRIFUGAL FIRE PUMPS, In-Line Type

Factory Mutual Research Approved in-line fire pumps are single stage pumps having the manufacturer-supplied vertical electric motor driving unit mounted directly on the pump, where the suction and discharge nozzles have a common horizontal centerline which intersects the motor shaft axis at a 90° angle.

Armstrong Darling Inc 23 Bertrand Ave Toronto Ontario Canada M1L 2P3

Rated Capacity, gal/min (dm³/min)	*Rated Net Head, psi (kPa)*	*Rated Speed, r/min*	*Type Designation*	*Suction Inlet, dia., in.*	*Discharge Outlet, dia., in.*
750 (2840)	77-115 (530-790)	3560	LB-F	6	4
750 (2840)	40-70 (275-480)	1780	LY-F	6	5

CENTRIFUGAL FIRE PUMPS, Horizontal Shaft, Limited Service

Horizontal shaft electric-motor-driven limited service fire pumps are of less capacity and are not substitutes for standard fire pumps. They are similar in design to standard fire pumps and must be under automatic control.

Patterson Pump Co, Sub Gorman-Rupp Co Box 790 Toccoa GA 30577

Rated Capacity gal/min (dm^3/min)	*Rated Net Head Pressure, psi (kPa)*	*Stage*	*Mfrs Size in. (mm)*	*Type Designation*	*Speeds Not Exceeding r/min*
200 (755)	50-100 (345-690)	1	3x2 (76x51)	MN	3600
300 (1135)	40-100 (275-690)	1	3x2 (76x51)	MN	3600
450 (1705)	40-75 (275-515)	1	4x4 (102x102)	MN	3600

CENTRIFUGAL FIRE PUMPS, Vertical Shaft, Turbine Type

Vertical shaft, turbine type centrifugal fire pumps have submerged impellers contained in a series-bowl assembly at the bottom of a vertical shaft. The design is similar to pumps used extensively for industrial and municipal service. These pumps are Factory Mutual Research Approved for discharging water from lakes, streams, open sumps, drilled wells and other equivalent subsurface sources. They are not Approved for taking suction from public mains or other positive suction pressure sources. The length of the column pipe must be specified when the pump is ordered.

Each pump consists of a discharge head, motor stand, column pipe, line shaft, bowl assembly and suction strainer. There are two types of discharge heads, one designed for direct connection to underground mains and the other for aboveground discharge.

In order to provide the pressure specified by the customer, the pump manufacturer may vary the number of stages or the impeller diameter or both from that shown in the listing.

For electric drive, Approved pumps must be used with a vertical, hollow shaft electric motor supplied with a built-in antireverse ratchet. The antireverse ratchet prevents the entire rotating assembly (rotor, shaft and impellers) from turning in the opposite direction. A tendency for the rotating assembly to turn in the opposite direction after stopping is caused by water draining from the column. A more strenuous attempt to turn in the opposite direction occurs if the electric motor tries to drive in reverse as a result of wiring changes, for example. In this more serious case, the antireverse ratchet *must be able to hold against the full starting torque of the motor* until overload protection de-energizes the motor. This type of motor is also equipped with thrust bearings to carry the load of the rotating parts in addition to the hydraulic thrust of the pump.

For internal-combustion-engine drive, Approved pumps must be connected to the Approved engine through an Approved right-angle gear drive. These gear drives have similar antireverse and thrust bearing characteristics to those described for electric-motor-driven assemblies.

Audoli & Bertola Corso Vercelli N 251 10155 Torino Italy

Rated Capacity, gal/min (dm^3/min)	*Mfrs. Size, in. (mm)*	*Type Designation*	*Rated Speed, r/min*	*Stages*	*Total Head, psi, at Rated Capacity (kPa)*
500 (1895)	5 (125)	VAB 152	1480	2-7	40-165 (275-1140)
500 (1895)	5 (125)	VAB 152	1770	2-7	49-247 (340-1705)
750 (2840)	5 (125)	VAB 152	1770	2-7	60-245 (415-1690)
750 (2840)	8 (200)	VAB 180	1480	2-8	40-170 (275-1170)
750 (2840)	8 (200)	VAB 180	1770	2-8	49-250 (340-1725)
1000 (3785)	8 (200)	VAB 180	1480	3-9	56-177 (385-1220)
1000 (3785)	8 (200)	VAB 180	1770	2-8	46-235 (315-1620)
1250 (4730)	8 (200)	VAB 180	1770	2-8	54-216 (370-1490)
1000 (3785)	8* (200)	VAB 200	1480	2-5	51-169 (350-1165)
1250 (4730)	8* (200)	VAB 200	1480	2-6	49-178 (340-1227)
1250 (4730)	8* (200)	VAB 200	1770	2-5	72-240 (495-1655)
1500 (5680)	8* (200)	VAB 200	1480	6	168 (1160)
1500 (5680)	8* (200)	VAB 200	1770	2-5	71-229 (490-1580)
1500 (5680)	12 (305)	VAB 250	1480	1-3	40-134 (275-925)
1500 (5680)	12 (305)	VAB 250	1770	1-3	40-197 (275-1360)
1750 (6625)	12 (305)	VAB 250	1480	1-3	40-132 (275-910)
1750 (6625)	12 (305)	VAB 250	1770	1-3	40-194 (275-1340)
2000 (7570)	12 (305)	VAB 250	1480	2-3	66-129 (455-890)
2000 (7570)	12 (305)	VAB 250	1770	1-3	40-190 (275-1310)
2250 (8515)	12 (305)	VAB 250	1770	1-3	40-185 (275-1275)
2250 (8515)	12 (305)	VAB251	1480	2-5	73-197 (505-1360)
2500 (9465)	12 (305)	VAB 250	1770	1-3	44-181 (305-1250)
2500 (9465)	12 (305)	VAB251	1480	2-5	70-191 (485-1315)
2500 (9465)	12 (305)	VAB 302	1480	1-3	40-138 (275-950)
2500 (9465)	12 (305)	VAB 302	1770	1-2	49-135 (340-930)
3000 (11 355)	12 (305)	VAB 302	1480	2-3	65-174 (450-1200)
3000 (11 355)	12 (305)	VAB 302	1770	1-2	46-132 (315-910)
3000 (11 355)	12 (305)	VAB251	1770	1-4	51-221 (350-1525)
3500 (13 250)	12 (305)	VAB 302	1480	3	119 (820)
3500 (13 250)	12 (305)	VAB 302	1770	1-2	43-187 (295-1290)
4000 (15 140)	12 (305)	VAB302	1770	1-3	51-182 (350-1255)

*When power is greater than 140 bhp (190 kW), uses 12 in. (300 mm) discharge head.

Aurora Pump, A Member of the Pentair Pump Group 800 Airport Rd North Aurora IL 60542

500 (1895)	11 (279)	11FGM	1770	–	100-370 (690-2550)
500 (1895)	12 (305)	12FRKLC	1770	4-10	91-277 (625-1910)
750 (2840)	12 (305)	12FCM	1770	–	99-387 (685-2670)
750 (2840)	12 (305)	12FRKMC	1770	4-8	110-237 (760-1635)

Rated Capacity, gal/min (dm³/min)	*Mfrs. Size, in (mm)*	*Type Designation*	*Rated Speed, r/min*	*Stages*	*Total Head, psi, at Rated Capacity (kPa)*
1500 (5680)	14 (356)	GH14H a†	1790	2-3	80-125 (550-860)
1500 (5680)	14 (356)	PE14D	1760	—	104-190 (715-1310)
1500 (5680)	14 (356)	GH14H a†	1480	2-6	54-165 (370-1140)
2000 (7570)	18 (455)	PE18E b	1460	2-5	70-239 (485-1650)
2000 (7570)	16 (406)	PE16B	1760	—	104-262 (715-1805)
2000 (7570)	12 (305)	GL12F a†	1418, 1480	2-3	113-195 (780-1345)
2000 (7570)	14 (356)	PE14G	1760	2-6	61-270 (420-1860)
2500 (9465)	12 (305)	GL12F a†	1418, 1480	2-3	108-190 (745-1310)
2500 (9465)	18 (455)	PE18E b	1460	2-5	64-224 (440-1545)
2500 (9465)	16 (406)	PE16E	1760	—	104-205 (715-1415)
3000 (11 355)	12 (305)	GL12F a†	1418, 1480	2-3	104-184 (715-1270)
3000 (11 355)	20 (508)	PE20K	1760	—	117-151 (805-1040)
3000 (11 355)	18 (455)	PE18E b	1460	2-5	61-204 (420-1405)
3500 (13 250)	12 (305)	GL12F a†	1418, 1480	2-3	97-175 (670-1205)
3500 (13 250)	18 (457)	PE18E ab	1760	—	104-182 (715-1255)
3500 (13 250)	20 (508)	PE20K	1760	—	112-147 (770-1015)
4000 (15 140)	20 (508)	PE20K	1760	—	108-142 (745-980)
4500 (17 035)	20 (508)	PE20K	1760	—	104-138 (715-950)
5000 (18 925)	20 (508)	PE20K	1760	—	134 (925)

a Available only with water-lubricated open line shaft construction
b Min submergence 2 ft (0 6 m)
†These designations have (FM) following the Designation No

CENTRIFUGAL FIRE PUMPS, Vertical Shaft, Turbine Type, Barrel

Vertical turbine barrel fire pumps have submerged impellers contained in a series–bowl assembly enclosed within a barrel. The barrel is bolted to the discharge head which contains inlet and outlet flanges plus a support for hollow shaft electric motor or Approved right angle gear drive. The motor requirements for vertical shaft, turbine type, centrifugal fire pumps also apply to vertical turbine barrel pumps (see previous category).

They are Approved for taking suction from public mains or other positive suction pressure sources.

By varying the number of stages or the impeller diameter or both, the manufacturer may provide any rated pressure within the listed pressure range.

These pumps are also referred to as Vertical Turbine Can Fire Pumps.

Floway Pumps 2494 S Railroad Ave Box 164 Fresno CA 93707

Rated Capacity, gal/min (dm³/min)	*Type Designation*	*Rated Speed, r/min*	*Stages*	*Total Head, psi at Rated Capacity (kPa)*
750 (2840)	12 LKM-FP	1770	3-15	69-479 (475-3300)

DIESEL ENGINES for Fire Pump Drivers

The diesel engines listed below are Factory Mutual Research Approved as fire pump drivers for installations requiring internal combustion engine drive. The stated rated horsepower represents power available to the pump at NFPA standard installation conditions, 300 ft (91 m) above sea level and at 77°F (25°C). Allowances have been made for power consumption by accessories, normal engine wear and manufacturing tolerances.

The engine selected for a particular installation should provide at least as much rated power as the maximum power requirement of the pump to which it will be coupled.

Caterpillar Inc Engine Div 100 NE Adams St Peoria IL 61629

Product Designation	*Rated Power, hp (kW)*	*Rated Speed r/min*
3208 DINA (175)	101	1460
PL4925-XX, OT4931	(75)	
3208 DINA (175)	121	1750
PL4925-XX, OT4932	(90)	
3208 DINA (175)	130	1900
PL4925-XX, OT4933	(97)	
3208 DINA (175)	141	2100
PL4925-XX, OT4934	(105)	
3208 DINA (175)	145	2200
PL4925-XX, OT4935	(108)	
3208 DINA (175)	150	2300
PL4925-XX, OT4936	(112)	
3208 DINA (175)	156	2400
PL4925-XX, OT4937	(116)	
3208 DINA (175)	160	2600
PL4925-XX, OT4908	(119)	
3208 DINA (175)	165	2800
PL4925-XX, OT4696	(123)	
3208 DINA (175)	160	3000
PA4925-XX, OT7476	(119)	
3208 DINA (210)	122	1460
PL4926-XX, OT4939	(91)	
3208 DINA (210)	141	1750
PL4926-XX, OT4940	(105)	
3208 DINA (210)	150	1900
PL4926-XX, OT4941	(112)	
3208 DINA (210)	165	2100
PL4926-XX, OT4942	(123)	
3208 DINA (210)	170	2200
PL4926-XX, OT4943	(127)	
3208 DINA (210)	176	2300
PL4926-XX, OT4944	(131)	
3208 DINA (210)	180	2400
PL4926-XX, OT4945	(134)	
3208 DINA (210)	182	2600
PL4926-XX, OT4946	(136)	
3208 DINA (210)	187	2800
PL4926-XX, OT4695	(139)	
3208 DINA (210)	185	3000
PA4926-XX, OT7477	(138)	
3208 DIT	145	1460
PL4927-XX, OT4923	(108)	
3208 DIT	196	1750
PL4927-XX, OT4924	(146)	
3208 DIT	211	1900
PL4927-XX, OT4925	(157)	
3208 DIT	235	2100
PL4927-XX, OT4926	(175)	
3208 DIT	245	2200
PL4927-XX, OT4927	(183)	
3208 DIT	251	2300
PL4927-XX, OT4928	(187)	
3208 DIT	255	2400
PL4927-XX, OT4929	(190)	
3208 DIT	260	2600
PL4927-XX, OT4930	(194)	
3208 DIT	270	2800
PL4927-XX, OT4694	(201)	
3306 BDIT	195	1460
PA5904-XX, OT4715	(145)	
3306 BDIT	231	1750
PA5904-XX, OT4714	(172)	
3306 BDIT	247	1900
PA5904-XX, OT4949	(184)	
3306 BDIT	267	2100
PA5904-XX, OT4713	(199)	
3306 BDIT	272	2300
PA5904-XX, OT4712	(203)	

FLOWSERVE

Pump Division
Flowserve Pumps
IDP Pumps

Test Procedures

Flowserve Corp. #:
Model:
Customer:
Customer Order #:
Project:
Quantity Tested:

HYDROSTATIC TESTING
The above pumps will be hydraulically tested at XXXX psi with a hold time of XX minutes. A certified hydraulic sheet will be filled out and sent with documentation.

PERFORMANCE TESTING
The pumps listed above will be tested for performance in accordance with the attached typical procedure. Curves will be drawn from the test data to show the head, consumed power and efficiency vs. The flow.

Pumps may be tested at other than rated speed and data corrected to the rated speed using the affinity laws, as allowed by hydraulic institute standards under section 1.6.5.8.8. For variable speed applications, multispeed curves can be generated from test speed data by use of Affinity laws.

Npshr test will be conducted in conjunction with the performance test. A one point npshr test will be conducted by running out the flow to the point of creating an unstable or cavitation condition. The point at which a 3% head drop occurs shall be considered the point at which npsha is equal to npshr.

Pumps will be tested using calibrated shop driver. Pumps may be tested in horizontal or vertical position at option of manufacturer.

All testing is based on hydraulic institute test code.

Performance test may be witnessed by customer's representative.

FLOWSERVE

Pump Division
Flowserve Pumps
IDP Pumps

Pump Performance Test
Typical Test Procedures

The following are the primary parameters measured during our pump performance test.

1. **SUCTION HEAD**

Or A pressure transducer will be connected to a piezometer ring at the suction pipe. This gauge will read suction pressure in inches of Mercury.
Suction pressure will be referenced to the water level.

2. **DISCHARGE HEAD**

A direct reading calibrated Bourdon gauge or pressure transducer will be connected to a piezometer ring at the pump discharge pipe. This gauge will read discharge head in PSIG at the centerline of the gauge.

3. **CAPACITY**

A calibrated Venturi meter or magnetic flowmeter will be used to measure capacity.
Or A differential pressure transducer will be connected across a calibrated venturi on the discharge pipe. This gauge will read differential pressure in inches of mercury.

4. **SPEED**

A direct reading digital tachometer will be used to measure speed.

5. **POWER INPUT TO THE PUMP**

A Multilin relay (Total Measuring system supplied by GE for measuring power, voltage and current) will be used to measure the power input to the motor. The motor calibration curve will then be used to determine the power input into the pump.

6. **PUMP BRAKE HORSEPOWER**

A calibrated polyphase wattmeter or Multilin Relay will be used to measure electrical power into the motor used for test. Brake horsepower will be calculated as follows:

$$BHP = \frac{METER\ READING \times METER\ FACTOR}{1000 \times .7457} \times MOTOR\ EFFICIENCY$$

FLOWSERVE

Pump Division
Flowserve Pumps
IDP Pumps

TEST CARD READINGS

1.	SPEED:	Direct reading
2.	SUCTION:	Gage reading PSIG or IN-HG
3.	DISCHARGE:	Gage reading PSIG or IN-HG
4.	CAPACITY:	Venturi or Magnetic Flowmeter
5.	POWER:	Power meter reading
6.	TEMP:	Water temperature in degrees F.

CALCULATIONS

SPEED:	Direct reading
SUCTION HEAD:	0 at water level for performance
DISCHARGE HEAD:	For gage with readings corrected for gage calibration PSI x 2.31 = feet of water
CAPACITY:	Mercury to GPM for Venturi calibration
POWER:	Reading x power factor = input to motor in watts
	BHP = KW/.7457 x motor efficiency
TOTAL HEAD:	Discharge head - suction head + distance between gages + velocity head difference between discharge and suction at points of pressure measurement.
PUMP EFF:	$\frac{\text{GPM x TH}}{\text{3960 x BHP}}$

FLOWSERVE

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Flowserve Pumps
IDP Pumps

TEST DATA CARD

A. ORDER NO.:	Flowserve order number.
B. SERIAL NO.:	Pump serial number.
C. SIZE AND TYPE:	Pump size and type.
D. TEST DATE:	Date tested.
E. TEST ID:	Test Identification number.
F. # PTS.:	Number of test points.
G. RPM:	Operating speed to which data should be corrected.
H. BAROM:	Barometric pressure in "Hg.
I. SP GR:	Specific gravity of customers liquid.
J. VENT:	Code number of venturi, if used.
K. METER FACT:	Wattmeter multiplication factor, if used.
L. DRIVER:	Code number of test motor.
M. DBG:	Vertical distance in feet between the suction gauge connection and the discharge gauge zero.
N. SUCT. DIA.:	Diameter in inches of suction pipe (where readings are taken).
O. DISCH. DIA.:	Diameter in inches of discharge pipe (where readings are taken).
P. Z:	Vertical distance in feet from pump impeller datum to the suction gauge connection.

FLOWSERVE

Pump Division
Flowserve Pumps
IDP Pumps

SAMPLE CALCULATION

INPUT DATA TEST _____ POINT _____

SPEED POWER	SUCTION	DISCHARGE	CAPACITY
	/ ( )	/ ( )	/ ( )

CAPACITY

GPM = C · $\sqrt{"HG}$ (From Venturi Calibration)

=

TOTAL HEAD

TH (feet) = Discharge + Suction ± Gauge Elevation Difference

= (x 2.31) + (x 1.133) ±

=

HORSEPOWER

Input Watts = Meter Reading x Power Factor

= x

BHP = (KW/.7457) x Motor Efficiency =

EFFICIENCY - Pump

$$EFF = \frac{GPM \times TH}{3960 \times BHP}$$

$$= \frac{\quad x \quad}{3960 \times}$$

FLOWSERVE

Pump Division
Flowserve Pumps
IDP Pumps

TEST DATA CARD

Conditions of Service

GPM _____ Venturi _____ Wattmeter _____
TDH _____ Condition _____
EFF _____ Driver _____ HP Leads _____
BHP _____ _____ RPM Ct _____

Order No.	Serial No.	Size and Type	Test ID	Test Date	Time
A	B	C	D	E	

Number Of Points	RPM	Barom	Specific Gravity	Vent	Meter Fact	Driver	DBG	Suction Diameter	Discharge Diameter	Z
F	G	H	I	J	K	L	M	N	O	P

Point Number	RPM 1	Suction Pressure 2		Discharge Pressure 3			Capacity 4		Power 5		Temp 6
1		\		\			\				
2		\		\			\				
3		\		\			\				
4		\		\			\				
5		\		\			\				
6		\		\			\				
7		\		\			\				
8		\		\			\				
9		\		\			\				
10		\		\			\				
11		\		\			\				
12		\		\			\				
13		\		\			\				
14		\		\			\				
15		\		\			\				

Distance from ℄ of discharge gauge to water level _____ inches
Distance from ℄ suction piezometer ring to water level _____ inches
Distance from ℄ discharge pipe to water level _____ inches

TESTED BY: NAME (PRINT)

SIGNATURE: _____ DATE:

WITNESSED BY: NAME (PRINT)

SIGNATURE: _____ DATE:

FIRM:

FLOWSERVE

Pump Division
Flowserve Pumps
IDP Pumps

Hydrostatic Test Certification

Customer: _____ Customer Order: _____

Pump Model: _____ Taneytown Order: _____

Part No.: _____ Part Name: _____ Qty. _____

Part No.: _____ Part Name: _____ Qty. _____

Part No.: _____ Part Name: _____ Qty. _____

Part No.: _____ Part Name: _____ Qty. _____

Pressure: _____ Hold Time: _____ Min. _____

Procedure

Flowserve Pump Division hereby certifies that the material furnished on the above subject order was satisfactorily hydro tested per the above pressure and hold time.

_____ _____
Tester Date

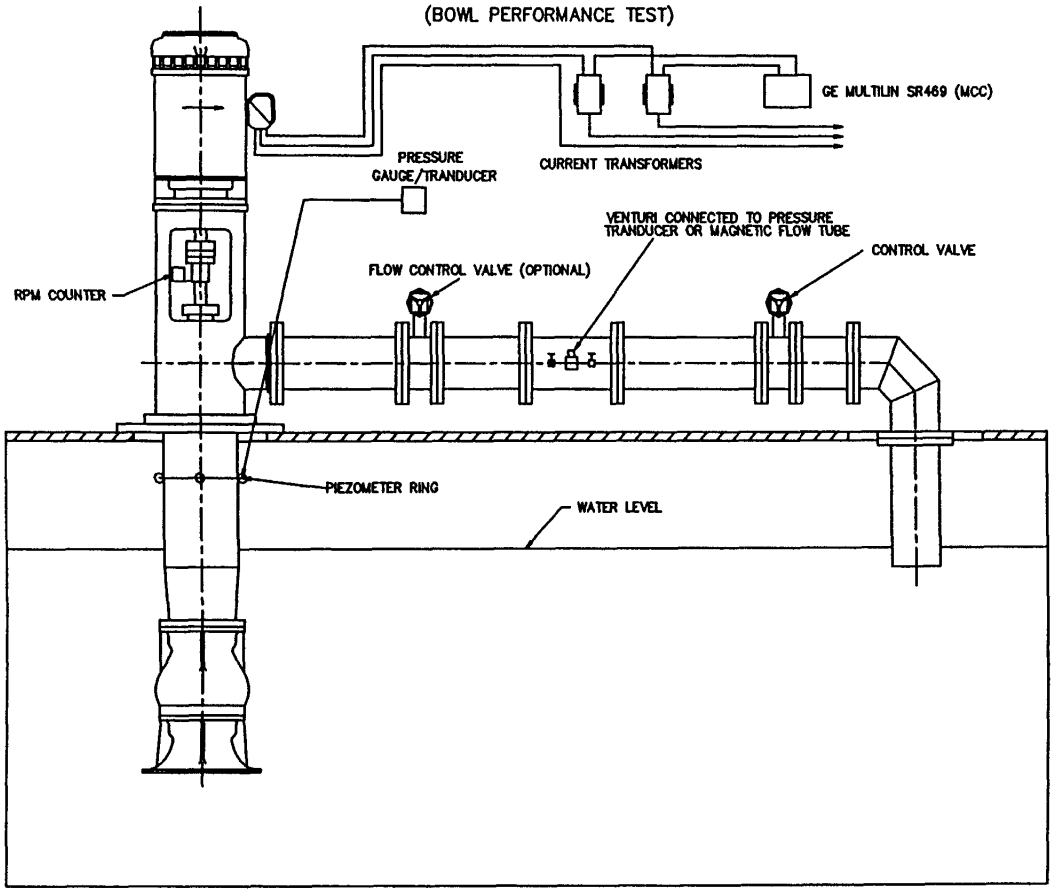
_____ _____
Witness (If requested) Date

_____ _____
Professional Engineer (If requested) Date

FLOWSERVE PUMP DIVISION

TEST LAB LAYOUT

(BOWL PERFORMANCE TEST)



PROCEDURE

Title	Procedure No
Test Specification for Centrifugal Pumps	**L 102-7E**
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TEST SPECIFICATION FOR CENTRIFUGAL PUMPS

Table of Content:

VALID	RELEASED	Written by	Released by
02 December 2002	02.December 2002	E. Schniedl	Chr. Rossegger

1 General

This specification applies to standard test runs for all horizontal and vertical single stage and multistage centrifugal pumps.

2 Brunn's Test Stand

2.1 General

Brunn's test stand is a closed loop test rig with two tanks. Tank 1 has a capacity of 50m³, tank 2 has a capacity of 20m³. Tank pressure can be between 0.2 and 2 bar absolute. Tests are performed with water at ambient temperature (20°C – 65°C). There is no possibility for a test run with another liquid or temperature. The tanks and piping system are situated below floor.
The general test limits are:
Power: 1000 kW
Flow: 2400 m³/h
Head: 1600 m
Test limits for a certain pump see chapter 2.2.

2.2 Testing Cells

The test stand is divided into 9 test cells for dedicated pump types and sizes.

Cell	Pump type	Arrangement	Power	Speed	max. Setting length
#			kW	rpm	m
1	ERPN	horizontal	22	0-3600	-
2	ERPN	horizontal	80	0-3600	-
3	ERPN, WX/WXB	horizontal	110	0-3600	-
4	ERPN, WX/WXB	horizontal	500	0-3600	-
5	WX/WXB	horizontal	1000	2950	-
6	ECPJ, WU/WUJ	vertical	400 500	1450, 2950	5
7	WU/WUJ	vertical	400 500	1450, 2950	5
8	MSP	horizontal	80	0-8000	-
9	Complete unit test	see 3.9.2	-	-	-

Max. suction and discharge diameter: DN 400
Discharge pressure control valves: p_{max} = 160 bar ,Q_{max} = 600 m³/h
p_{max} = 64 bar Q_{max} =1800 m³/h
p_{max} = 25 bar Q_{max} =2400 m³/h

3 Test Execution

3.1 Test Program

The test program is defined in the quality plan. The requirements of the quality plan are defined in the contract with the customer.
Every pump is tested non witnessed (performance test). For witnessed tests, following number of test runs is our standard:

number of pumps / order	number of witnessed test runs
1, 2, 3	1
4 – 10	2
more than 10	3

3.2 Preparation

The preparation of the pump for testing is done in the assembly area. Standard test is with original seal but without auxiliary piping. Flushing of the mechanical seal or packing is provided with flexible hoses. Additional equipment (like measuring instruments) is not mounted. Vertical pumps are tested without can.

3.3 Pump modifications

Tests are normally performed at actual conditions of service. In some cases there are differences in the following matters:
Suction pressure: between 0.2 and 2 bar abs.
Speed: possible test speed see chapter 2.2
Reduced number of stages or speed:
If the allowed load on the bearings or shaft is exceeded by a test with water (if the pumped liquid at site is below 1000 kg/m³), the number of stages or the speed will be reduced. This will be realized by reduction of the number of stages, the use of dummy stages or reduction of test speed. After the test, the measured values will be calculated to the conditions of service.
Also if the available power on the test stand will be exceeded by the maximum power consumption of the pump (running the pump with water), the test will be performed in this way.
Reduced setting length:
When the setting length of a vertical pump exceeds 5 m, it will be reduced by renounce of column pipes and line shafts.
Horizontal set up for vertical pumps:
Vertical pumps with a setting length longer than 5 m and without the possibility of length reduction are tested horizontally.

3.4 Test Set-up

Selection of the suitable testing cell, electric motor and discharge pressure reduction valve.
Mounting of pump and aligning of coupling.
Mounting of mech. seal flushing and auxiliary systems using operating manual.
Filling of bearing housing with lube oil.
Installation of suction and discharge piping with loop manifold connecting pressure taps (for vertical pumps only discharge piping required).
Connecting the pressure taps with the pressure gauges mounted on the wall by using a flexible tube
Filling of suction pipe and pump with water
Venting of pump and all piping systems
Filling of discharge pressure measuring tube and pressure gauge
Filling of suction pressure measuring tubes and pressure gauge for horizontal test or venting it for vertical tests
Closing of discharge pressure reduction valve
Checking direction of rotation

3.5 Starting of Pump

Starting motor
Checking discharge pressure (if discharge pressure doesn't increase, pump must be stopped immediately)
Opening discharge valve for medium flow
Checking tightness of pump, stuffing box, bearings and auxiliary systems
Waiting 30 minutes to start with performance- or NPSH-test

3.6 Starting Test

Switch on all measurement instruments and both measurement computers used for the test.
Checking the measurement instruments
Input of all relevant test data (see chapter 4) into the automatic data acquisition and test evaluation program.

3.7 Performance Test (Q - H Test)

Performance test is normally done with an open test loop (ambient pressure at the tank water level).
As a minimum 5 points are measured to define a test curve.
These five points are:

Flow Q	
Q_0	discharge valve closed
Q_{min}	minimum flow for continuous duty
$Q_{60\%}$	midway between minimum an rated flow

Q_{rated}	rated flow
$Q_{120\%}$	maximum allowable flow

Other measurement points can be selected as to obtain a smooth test curve.

Procedure:
The flow of each test point is set by opening or closing the discharge valve manually. When a new test point has been reached, it has to be checked for one minute that conditions are well balanced and then all 5 readings (suction pressure, discharge pressure, flow, torque or electric power, speed) are taken simultaneously by the automatic data acquisition program.
During test following additional measurements must be taken: water temperature and water level in the tank.
Test evaluation see chapter 4.1

3.8 Additional Tests

Following measurements are done during performance test:

3.8.1 Vibration and Bearing temperature

The unfiltered vibrations are measured during performance test in all test points except shut off. Measurement unit is vibration velocity in mm/s RMS. Probe locations are according to API 610.
Bearing temperature is measured during performance test.

3.9 Optional Tests

3.9.1 NPSH Test

Standard NPSH test is done for the rated flow. Other test points must be specified in the contract.
$NPSH_{required}$ for centrifugal pumps is defined with constant flow at a suction pressure were 3% drop in total head occurs. NPSH test is carried out in a closed test loop by evacuating the suction tank using a vacuum pump.
Pump set up is the same as for performance test.

Procedure:
The flow of the test point is set by opening or closing the discharge valve manually. After stabilization of flow the first point is measured (suction pressure, discharge pressure). Additionally the flow, motor speed, water temperature, ambient pressure and water level in the suction tank are measured. Then the vacuum pump is started. During drop down of suction pressure 7 points are measured. It must be guaranteed that the pump is cavitating at the latest measuring point 8. At each point suction pressure and discharge pressure are taken simultaneously by the automatic data acquisition program.
Test evaluation see chapter 4.2

3.9.2 Complete Unit Test

The pump and driver, complete with all auxiliaries that make up the unit are tested together. Performance test is done without measurement of efficiency (except a efficiency curve of electric motor is available).
Complete unit test is only possible if electric motor meets following conditions:

Low voltage motor:

Voltage:	between 380 V and 420 V (400 V at test)
Current	max. 1000A
Frequency	50 Hz

High voltage motor

Voltage:	between 6.0 kV and 6.6 kV (6.3 kV at test)
Current	max. 100A
Frequency	50 Hz

Motor power is sufficient to run the pump with water (density = 1000 kg/m³)

3.9.3 Mechanical run test

Test is included in performance test. Pump is driven by test motor, vibration and temperature are measured (refer to chapter 3.8 Additional Tests)

3.9.4 Sound Level Test

Measurement of sound pressure level at rated point (Standard is with test motor).. Measurement unit is dB (A). For further detail refer to Noise Test Procedure.

3.9.5 Submergence Test

Submergence test for vertical pumps is a performance test at rated point at minimum liquid level. This is done by lower the liquid level in the test-tank to submergence (minimum liquid level) of the pump. The test is passed, if the head is within the specified tolerance (standard tolerance according API 610 8th ed. table 4-2).

3.9.6 Filtered Vibration measurement (FFT Analysis)

Fast Fourier Transform (FFT) spectrum is made at each test point except shutoff. Probe location is according to API 610. The FFT spectra includes the range of frequencies from 5 Hz to 2Z times running speed (where Z is the number of impeller vanes). Measurement unit is vibration velocity mm/s RMS.

4 Test evaluation

4.1 Performance test evaluation

Performance test evaluation is done by the testing department using a MS-Excell program.
Following input parameter are necessary before test:
Order data
Rated values for flow, head, efficiency, power, speed NN [rpm], density SG [kg/m³]
Impeller diameter and type
Test motor number (for each test-motor motor-efficiency ETAM and wattmeter constant K are stored)
Diameter of suction pipe DS [mm], (for vertical pump arrangement DS = 100m to simulate the tank)
Diameter of discharge pipe DD [mm]
Distance between water level and manometer WL [m] (for horizontal pump test the distance is 0, because suction and discharge pressure gages are mounted on the same level)
Correction factors for viscosity (flow FQ, head FH, efficiency FETA)
Density of testing water WD [kg/m³] and gravity G [m/s²]

Following data are measured in each test point:
Flow QX [m³/h]
Suction pressure PS [bar g], Discharge pressure PD [bar g]
Torque Md [Nm] for test cells with torque-meter or electric power Pel [W] for vertical pumps
Speed at test NX [rpm]

Following values are calculated at each test point and converted to speed:
Capacity QU [m³/h]
Differential head HU [m]
Pump efficiency ETA [%]
Pump power PU [kW]

Following calculation formula are used:

QU = QX *	measured flow
* N * FQ	speed and viscosity correction
N=NN / NX	
HU = [(100000 * (PD-PS) / (G*WD)) +	static head
+ (((QX/3600)² (1/AD²-1/AS²)) / (2 * G)) +	dynamic head
+ WL] *	manometer distance
* N² * FH	speed and viscosity correction
AD = (DD/1000)² * π / 4	tube area at PD measurement
AS = (DS/1000)² * π / 4	tube area at PS measurement

PU =	P * SG / WD *	measured power
	* N^3 * FH * FQ / FETA	speed and viscosity correction
	P = K * Pel * ETAM * 0.01	for wattmeter measurement
	P = Md * NX * (π / 30) / 1000	for torque-meter measurement

ETA = (QU/3600) * HU * SG * G / (PU * 1000) * 100 pump efficiency

Measured and calculated values are printed out on a test record. Quality department controls the test result and verify if it is within the specified limits. Standard limits are according to API 610.

4.2 NPSH test evaluation

NPSH test evaluation is done by the testing department using a MS-Excel program.
Following input parameter are necessary before test:
Order data
Rated values for NPSH required, flow and speed
Relation point for NPSH (standard is centerline first stage)
Distance between centerline first stage and relation point for NPSH (DRP [m])
Impeller diameter
Test motor number
Diameter of suction pipe DS [mm], (for vertical pump arrangement DS = 100m to simulate the tank)
Diameter of discharge pipe DD [mm]
Distance between water level and manometer WL [m] (for horizontal pump test the distance is 0, because suction and discharge pressure gages are mounted on the same level)
Distance between centerline first stage and manometer CL [m]
Temperature of testing water (vapor pressure VP [Pa] is calculated by program)
Density of testing water WD [kg/m^3] and gravity G [m/s^2]
NPSH criteria (standard criteria is is a head loss of 3%)

Following data are measured at the first test point:
Flow at test, speed at test,
Barometric pressure BP [mm Hg]

Following data are measured at each test point:
Suction pressure PS [bar g]
Discharge pressure PD [bar g]

Following values are calculated at each test point and converted to speed:
Differential head HU [m]
NPSH Value [m]
Reduction of head PR [%]
Following calculation formula are used:

HU: same formula as used for performance test

NPSH: [(100000*PS + BP*132.7) / (G*WD) + static suction head
+ (62544 * Q^2) / (DS^4 * G) – dynamic suction head
– VP / (G*WD) + vapor pressure
+ CL – WL] * water level above first stage
* (NN / NX)^2 speed correction

PR[#] = (HU[1] – HU[#]) / HU[1] * 100 [#]... test point number

Program calculates the NPSH 3% point, so it is not necessary that this point is tested exactly.

Measured and calculated values are printed out on a test record. Quality department controls the test result and verify if it is within the specified limits. Standard limits are according to API 610.

4.3 Mechanical running certificate

Unfiltered vibration and bearing temperature are reported in the mechanical running test certificate. Quality department controls the test result and verify if it is within the specified limits. Standard limits are according to API 610.

5 Measurement equipment

5.1 Flow measurement

Magnetic Inductive Flowmeter (Fa. Turbo Messtechnik)

#	Range [m³/h]
1	0 - 45
2	0 - 120
3	0 - 300
4	0 -600
5	0 -1800

For higher flow it is possible to operate flowmeter #4 and #5 in parallel.

5.2 Pressure measurement

Wire resistance strain pressure sensors (Fa. Hottinger Baldwin)

#	Range [bar]
1	0 - 5
2	0 - 10
3	0 - 20
4	0 - 50
5	0 - 200

5.3 Power measurement

Horizontal arrangement:
Torquemeter with integrated speed measurement (Fa. Hottinger Baldwin)

#	range [Nm]
Cell 1	0 - 50
Cell 2	0 - 1000
Cell 3	0 - 1000
Cell 4 & 5	0 - 5000

Vertical arrangement
Calibrated motors with wattmeter (three watt meter method) (Fa. LEM-Norma)

#	Power [kW]	Speed [rpm]
11	4	1450
12	5,5	2950
13	5,5	1450
14	15	2950
15	45	1450
16	45	2950
17	75	2950
18	132	1450
19	160	2950
20	400	1450
21	500	2950

5.4 Additional measurements

Speed:	stroboscopic speed measurement instrument
Temperature:	PT 100 probe
Vibration:	unfiltered vibration (RMS) measurement instrument vibration measurement with computer calculated Fast Fourier Transformation (FFT) spectrum.
Noise:	Sound level meter (Bruel & Kjaer precission sound level meter 2215 with octave band filter)

5.5 Data acquisition system and test evaluation program

The measuring signal of flow, suction pressure, discharge pressure, torque and speed of horizontal arrangement are directly processed in a digital signal conditioner and sent to computer via parallel port. The measuring signal of electric motor power is sent to computer via serial port. The readings of speed for vertical arrangement and water temperature are done manually and put into test evaluation program.

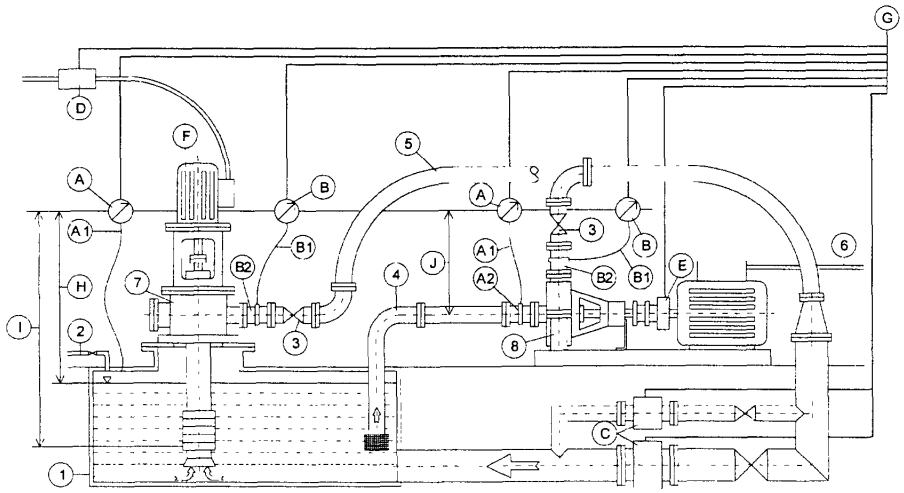
Test evaluation is done by computer with a special test evaluation program. This program is used for performance test and NPSH test. Test evaluation is divided into two steps. Automatic data acquisition is done by computer A, calculation of performance curve and NPSH curve is done by computer B. Both computers are connected together via intranet.

5.6 Calibration

All testing equipment (flow-meter, pressure gauge, torque-meter, speed counter,, vertical motors, Wattmeter, vibration measurement system, temperature probe, noise level measurement system) used for tests is subject to a periodical calibration program according to the Quality Management System ISO 9000.

6 Test Arrangement for Centrifugal Pumps

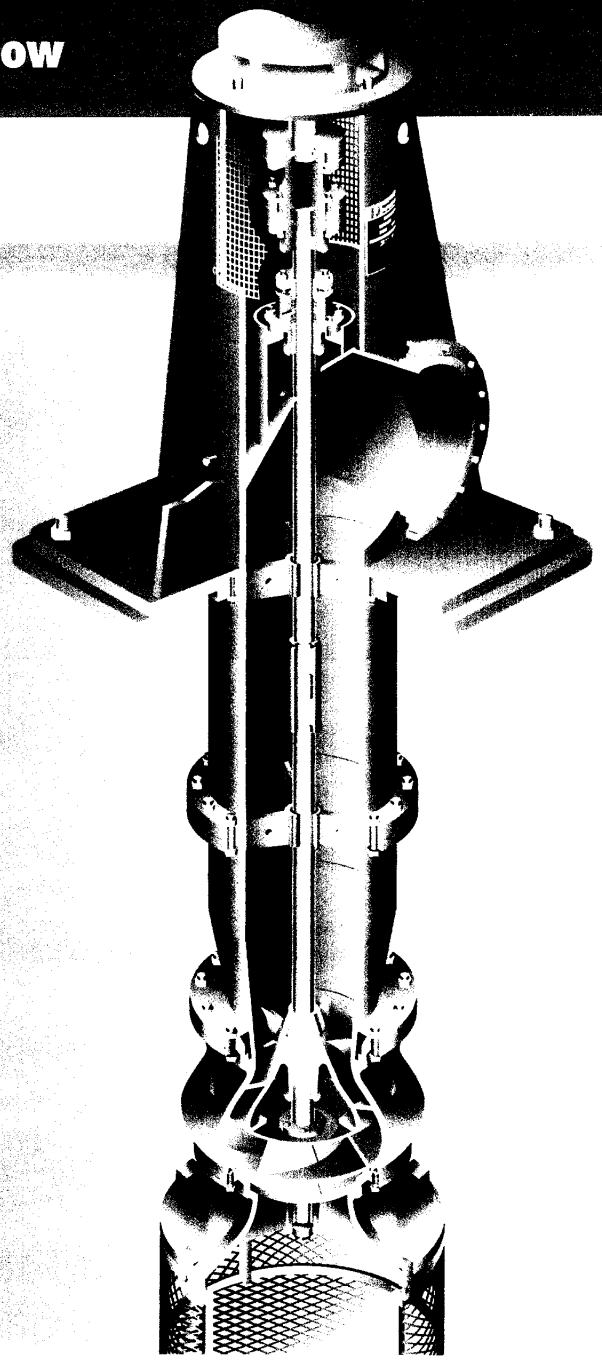
See Figure 1
A..... Suction pressure sensor
A1..... Connection tube (filled with water for horizontal pump tests, filled with air for vertical pump tests)
A2..... Loop manifold connecting suction pressure taps
B.. . Discharge pressure sensor
B1..... Connection tube (filled with water for horizontal and vertical pump tests)
B2..... Loop manifold connecting discharge pressure taps
C .. .. Magnetic inductive flow meter
D..... Watt meter (3 watt meter method)
E . ... . Torque meter and speed sensor
F .... Calibrated test motor
G..... Connection to the automatic data acquisition system
H..... ... Distance between water level and manometer (for vertical pump test)
I..... Distance between centerline first stage impeller and manometer (vertical test)
J..... Distance between centerline and manometer (horizontal pump test)
1..... Test tank
2..... Connection to the vacuum pump
3..... Discharge pressure reduction valve
4..... Suction piping connection for horizontal pump tests
5. .. ... . Flexible discharge piping system
6.... ..... Electric power supply from variable frequency converter
7. ..... Vertical test pump, installed in the test tank without can
8..... Horizontal test pump, installed on the test bad
Figure 1: Test arrangement for vertical and horizontal pump test



Ingersoll-Dresser Pumps

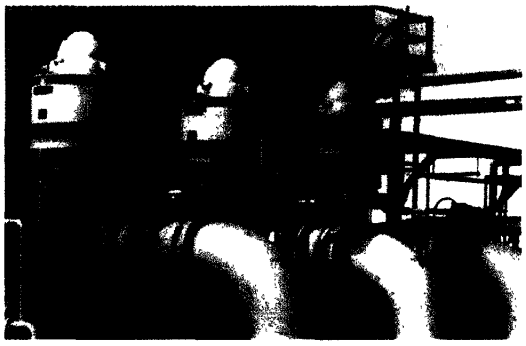
6″-48″ VTP Vertical Turbine Pumps

Mixed/Axial Flow



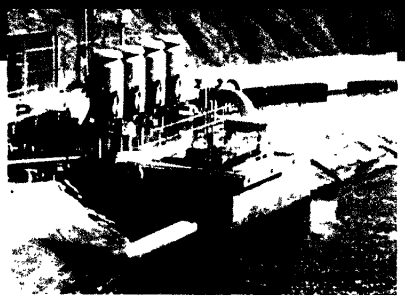
Versatility In Applications

INGERSOLL-DRESSER PUMP COMPANY manufactures one of the world's most comprehensive lines of vertical turbine, mixed and axial flow pumps. We have integrated the best features of our INGERSOLL-RAND and WORTHINGTON brand pump product lines to produce a reliable, efficient and competitive pump for the marketplace. Our vertical pumps are used worldwide in various applications for process, power, municipal, industrial, metals, recreational and irrigation services.



Cogeneration, 34 inch two stage VTP with 1500 hp driver 15,000 gpm (3400 cu.m/hr.) at 325 ft. (100 m)

Mu[illegible] 140 ft. (42.5 m)



Mining, 20 inch four stage VTP with 1250 hp driver 6000 gpm (1360 cu.m/hr.) at 640 ft. (195 m)

INGERSOLL-DRESSER PUMPS offers its vertical pumps in a wide range of configurations, construction and materials. They are typically installed in an open sump or deep well where the net positive suction head available is usually not a problem. However, when a wet well is not available, or if there is insufficient net positive suction head, the pump can be mounted in a suction barrel or can, which serves as the holding vessel for the liquid.

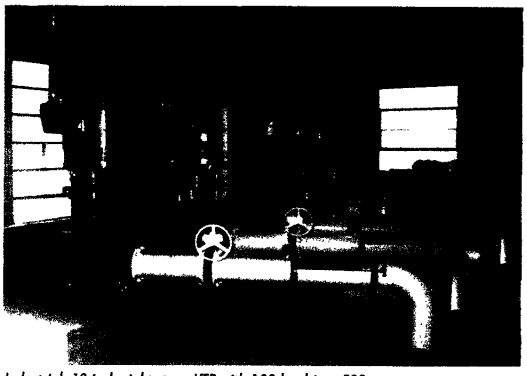
Impeller options include enclosed, open or semi-open designs. The lineshaft construction can be open, or enclosed for better lubrication of the lineshaft bearings in abrasive services. Flanged or threaded column pipe is used, and the discharge head is either cast iron or fabricated steel. Above or below grade discharge variations are also available.

The standard materials of construction used for most water services are cast iron bowls, bronze impellers, steel column and either a cast iron or fabricated steel discharge head. However, other material options such as bronze and stainless steel alloys are also available for more severe applications. In addition, special coating systems are available for corrosive liquids.

VERTICAL PUMP APPLICATIONS INCLUDE:

- *raw water intake (fresh or seawater)*
- *fresh water supply and distribution*
- *irrigation and sprinkler service for fire protection*
- *cooling tower, condensate, heater drain and make-up water*
- *API 610 process services for refineries, pipelines, production and petrochemical**
- *transfer, loading and unloading*
- *dewatering and cofferdam service*
- *screen wash service*
- *automotive production line lubrication*
- *snow-making*
- *steel mill cooling and quench services*
- *mine dewatering and acid leaching*
- *industrial process services*
- *brine recirculation and membrane booster*
- *secondary effluent*

**Detailed product information is available in Form No. 75068-A-VTP-API.*



Industrial, 10 inch eight stage VTP with 100 hp driver 500 gpm (110 cu.m/hr.) at 240 ft. (73 m)

Unsurpassed Hydraulic Coverage

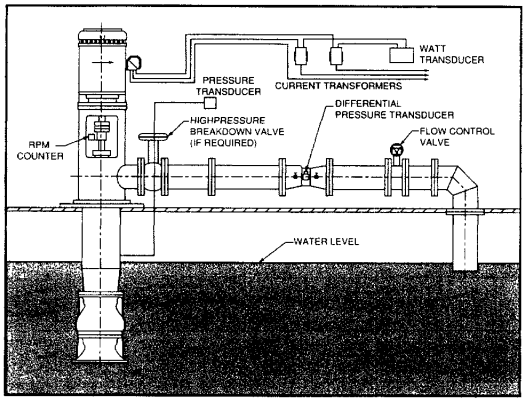
INGERSOLL-DRESSER PUMP COMPANY'S line of vertical turbine, mixed and axial flow pumps offers over 300 bowl and impeller medium capacity designs ranging through 60,000 gallons per minute (13,500 cu.m/hr.), heads up to 350 ft. (110 m) per stage and specific speed from 1400 to 12,500.* This unsurpassed coverage ensures you of finding the best pump selection to meet your requirements. The pumps can be driven by a variety of methods such as electric motors, dry or submersible, operating on either 50 Hz or 60 Hz power supply. Variable speed drives, engines with right angle gears, or steam turbines can also be used. Through proper selection of the pump and driver, the equipment will provide a broad and efficient operating range to match your system demand.

This table illustrates the specific speed range of our hydraulic coverage.

Bowl Designation	*Specific Speed Range*
HK	*1400-1800*
L	*1500-1800*
JK	*1801-2300*
M	*2250-2500*
KK	*2301-2800*
LK	*2801-3400*
H	*2900-3900*
NK	*3401-4000*
PK	*4001-4700*
HH	*4200-4700*
Q	*4701-5500*
HHH	*5000-5200*
RS	*5501-6500*
TS	*8001-10,000*

Performance Test Capabilities

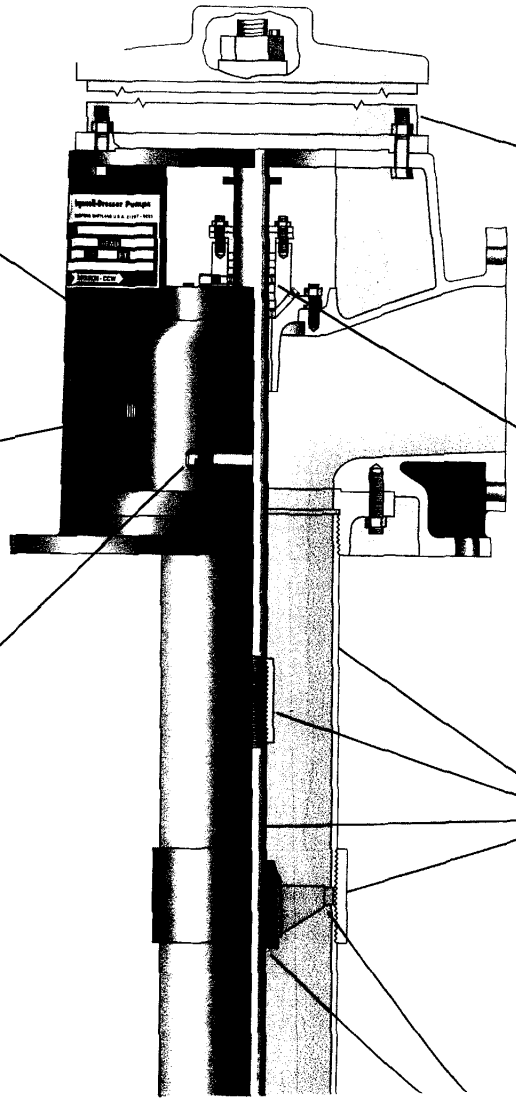
INGERSOLL-DRESSER PUMPS has done extensive performance testing of its vertical pump line to optimize our hydraulic designs and impeller selection. We have several test stands which offer various options to meet your needs.



- *Four worldwide laboratories for performance or NPSH testing; Complete or partial assembled unit testing using either a shop or job motor.**
- *Flows up to 60,000 gpm (3800 l/sec), measured with transducers or flow venturi meters.*
- *Pressures up to 1200 psi (85 kg/sqcm), measured with pressure transducers.*
- *Calibrated motors from 720 rpm to 3600 rpm, 60 cycle and 50 cycle.*
- *Test voltages from 230V to 4160V.*
- *Electronically generated test data and performance curves.*
- *Various sizes of flow venturi meters for more accurate readings on a range of flows.*
- *Strobe light and digital tachometer for speed measurement.*
- *Test codes per HI, AWWA, ANSI, API and ASME-PTC.*

**Ingersoll-Dresser Pump's Engineered Product Group manufactures high capacity vertical products from 60,000 gpm (13,500 cu.m/hr.) through 750,000 gpm (160,000 cu.m/hr.). Testing capabilities in excess of the values listed above are also available. Information can be obtained from our sales associates upon request.*

Typical Multi-Stage Vertical Turbine Pump With Product Lubrication



Cast Iron Discharge Head with 125# or 250# Flat Face Flange provides a smooth transition of the pumped liquid into the discharge piping. It also functions as a mounting base for the driver.

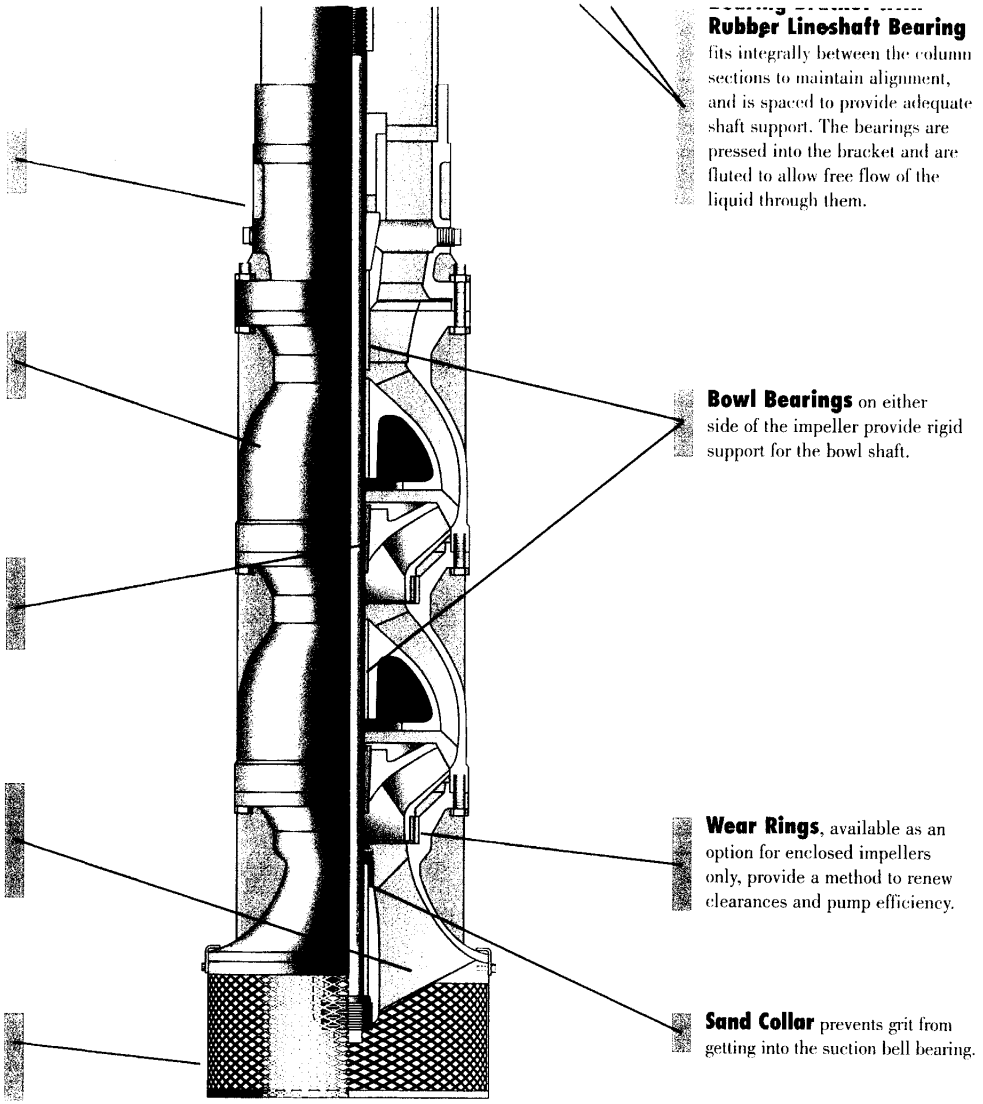
Prelubrication Connection allows connection to an external lubrication source for deep set pumps.

Lifting Pins which are held in place by brackets cast integrally with the discharge head provide for safe installation.

Vertical Hollow Shaft Motor allows the pump headshaft to extend through the motor and provides impeller clearance adjustment with an adjusting nut located at the top of the motor. A two piece headshaft with a motor stand is available when overhead clearance is inadequate to remove the motor. Motor steady bushings are recommended when using a two piece headshaft at running speeds of 1200 rpm and higher.

High Pressure Stuffing Box is adequate for working pressures up to 300 psi. Other stuffing box options are also available.

Open Lineshaft Construction shown with threaded steel lineshaft allows the lineshaft bearings to be lubricated by the pumped liquid. Threaded column pipe minimizes the well casing diameter required for well pumps.



Discharge Case allows adaptation of the bowl to various column sizes.

Intermediate Bowl Stages allow flexibility in meeting the required system head.

Lock Collet provides an interference fit between the bowl shaft and impeller to hold the impeller securely in place.

Suction Bell is designed to provide efficient flow of the liquid into the eye of the first stage impeller. A suction case is also available for well pump applications.

Basket Strainer prevents unwanted debris from getting into the pump. It is designed to exceed the parameters in Hydraulics Institute.

Rubber Lineshaft Bearing fits integrally between the column sections to maintain alignment, and is spaced to provide adequate shaft support. The bearings are pressed into the bracket and are fluted to allow free flow of the liquid through them.

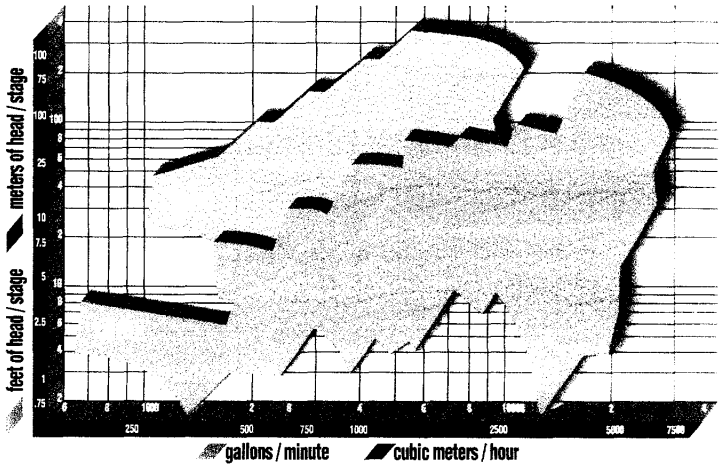
Bowl Bearings on either side of the impeller provide rigid support for the bowl shaft.

Wear Rings, available as an option for enclosed impellers only, provide a method to renew clearances and pump efficiency.

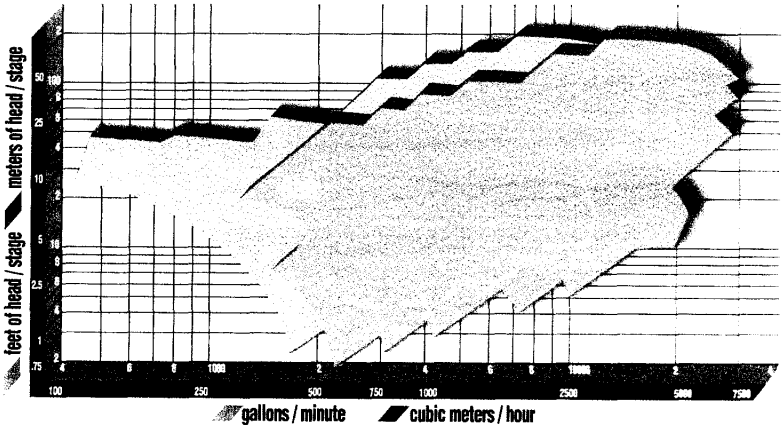
Sand Collar prevents grit from getting into the suction bell bearing.

Ingersoll-Dresser Pumps

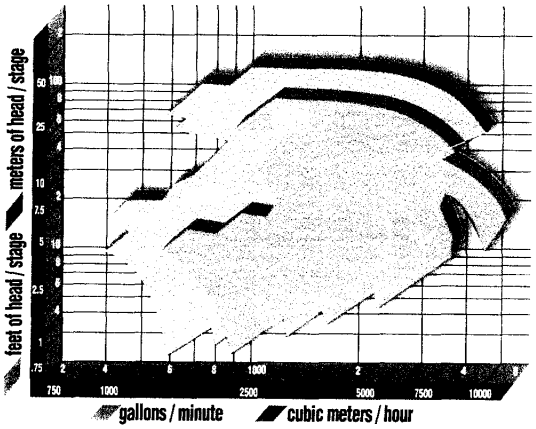
3600 & 1800 RPM



1180 & 880 RPM



710 & 590 RPM



Typical Multi-Stage Vertical Turbine Can Pump

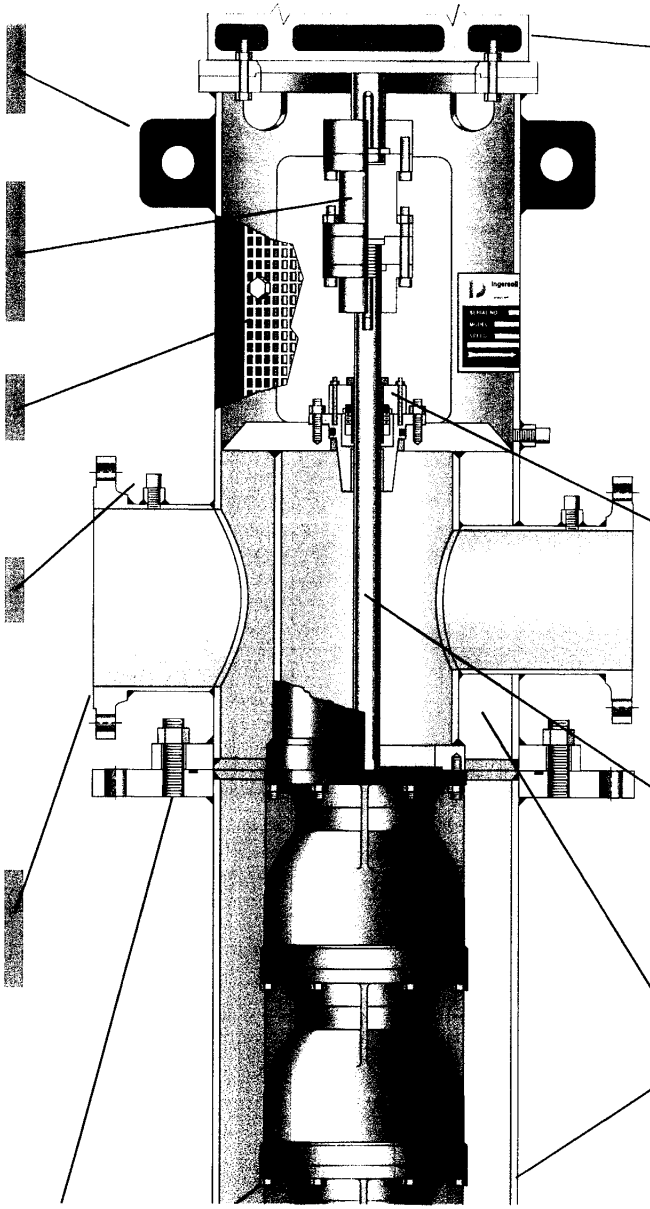
Lifting Lugs are integral to the discharge head. They provide a safe means for raising or lowering the pump into position.

Rigid Adjustable Spacer Coupling provides accurate impeller clearance adjustment along with stability. The spacer allows access to the mechanical seal without removing the motor.

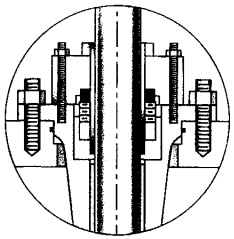
OSHA Coupling Guard provides safety while allowing visual inspection of the coupling.

Pressure Gauge Taps are provided on the suction and discharge nozzles of the discharge head.

150#, 300# or 600# Raised Face Suction and Discharge Flanges provide proper connection to high pressure piping.



Vertical Solid Shaft Motor with low runout tolerance contributes to low vibration levels.

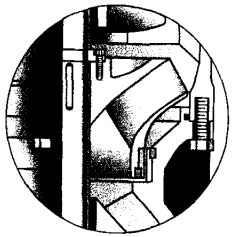


Cartridge Mechanical Seal is used to prevent leakage in the stuffing box area which occurs with packing. This is especially desirable when pumping volatile or toxic liquids. They are available from a wide range of manufacturers with a variety of types and materials. The mechanical seal housing used in our vertical turbine pumps can be machined and adapted to fit the dimensions of the seal. Mechanical seals are an optional feature for all pump sizes.

One Piece Pump Shaft eliminates the need for lineshaft couplings which cause increased shaft runout, higher vibration and misalignment.

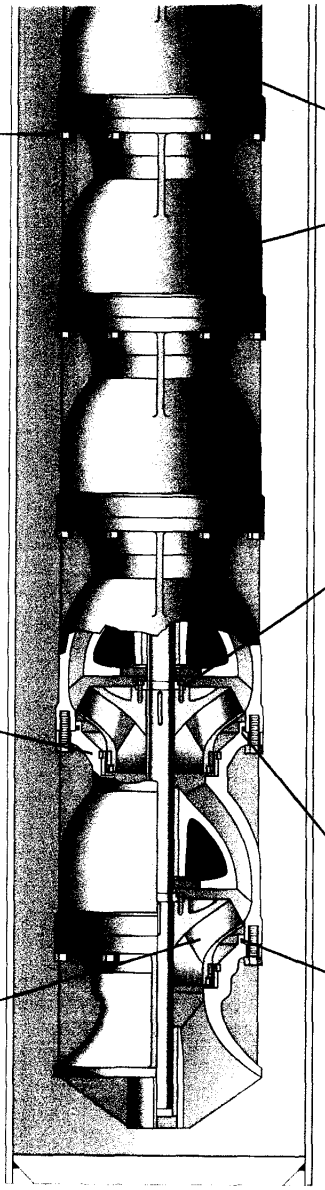
Discharge Head and Suction Can heavy-duty, stress relieved construction are designed to provide pressure containment for the pumped liquid.

Stainless Steel Fasteners resist corrosion and allow ease of maintenance.



Pinned Bowl and Impeller Wear Rings, available as an option for enclosed impellers only, provide a method to renew clearances and pump efficiency. Set screws or spring roll pins positively lock the bowl and impeller rings in place thus preventing the problems associated with contact and thermal expansion. A variance in hardness of greater than Brinell 50 between the rings prevents them from galling. Wear rings are an optional feature for all pump sizes.

First Stage Low Net Positive Suction Head Required impellers are available which minimize the can length to meet the system NPSH requirements.

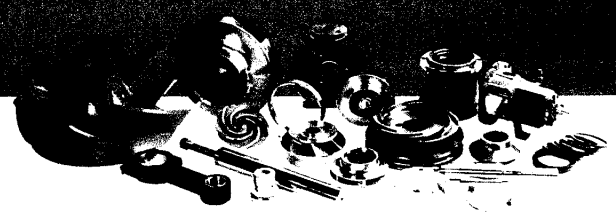


Intermediate Stages provide the differential pressure required by the system.

Keyed Impellers are positively locked to the shaft to eliminate any undesired movement. They are standard construction for 18" and larger pump sizes and optional for the other sizes.

O-Rings seated in machined grooves provide a positive seal between the pump stages and are available as an option.

Our Total Commitment to Customer Service

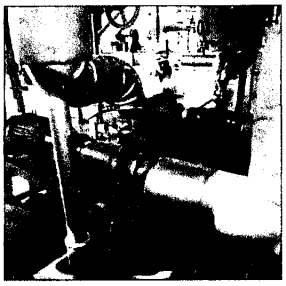


Ingersoll-Dresser Pumps' support services are focused on you, our customer.

Our parts supply and manufacturing facilities, located throughout the world, are geared to provide high quality OEM parts. Computerized quotation and order fulfillment programs provide timely pricing and order entry.

In addition to providing quality OEM parts, Ingersoll-Dresser Pumps offers expert repairs (both at our Pump Service Facilities and on-site), cost-effective upgrades and extensive aftermarket services that include:

- Complete design analyses of critical pumping systems
- Detailed pump condition assessment and quality repair
- Pump monitoring and predictive maintenance systems
- Complete parts inventory management programs
- Single point project management for expeditious handling of hard-ware purchases, repairs, upgrades, and technical support



All of these services and more are aimed at optimizing <u>your</u> pump and system performance.

We're customer focused — worldwide!

Ingersoll-Rand • Pacific • Worthington • Pleuger • Scienco • Jeumont-Schneider Pumps

Ingersoll-Dresser Pumps

North America:
(1)800-728-PUMP

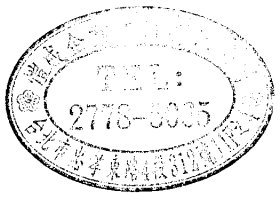
Latin America:
(1)713-803-4400

Europe, Middle East, Africa:
(44)1204-690-524

Asia:
(65)775-3003

Form TTX1440A-050400-EN Printed in USA

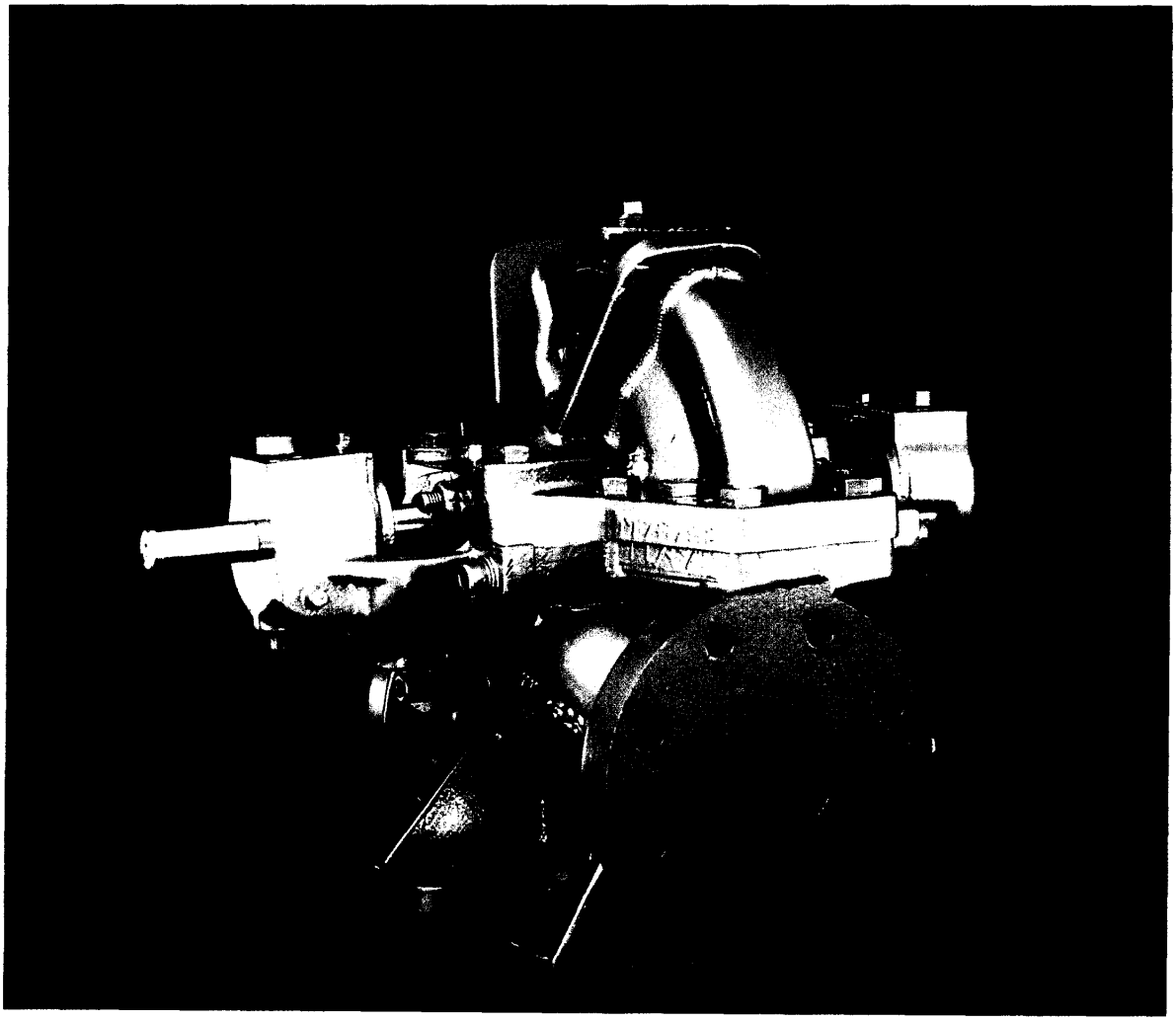
Representative



Ingersoll-Dresser Pumps

centrifugal, horizontal split-case pumps

TYPES LR/LLR



Sizes 1½ to 16 inches • capacities to 20,000 gpm • heads to 1,000 feet

Ingersoll-Dresser Pump Company

A broad line of field proven, split-case pumps for a wide variety of applications

The LR/LLR line offers you 39 horizontal and 14 vertical sizes with capacities to 20,000 gpm, heads to 1,000 feet, in sizes 1½" through 16". Larger custom-engineered sizes are available to 50,000 gpm, heads to 600 feet, and sizes to 36".

LR split-case pumps offer many benefits. They provide a wider range of hydraulic coverage than other typical horizontal split-case pumps and end-suction designs. Split-case pumps minimize the effects of radial load by allowing the radial thrust to be shared equally by the bearings at each end of the shaft. This results in much longer bearing life than end-suction designs where one bearing must support 2 times the radial load of the impeller. Split-case designs allow for balanced axial loading, high efficiency and low NPSH with double-suction closed impellers. Rugged, heavy-duty construction coupled with superior design features make this line of pumps very reliable. Low initial investment and high efficiency make overall cost very attractive.

Type LR horizontal split-case pumps are designed to ensure ease of maintenance and parts interchangeability. That means additional savings through reduced downtime and minimum parts inventory.

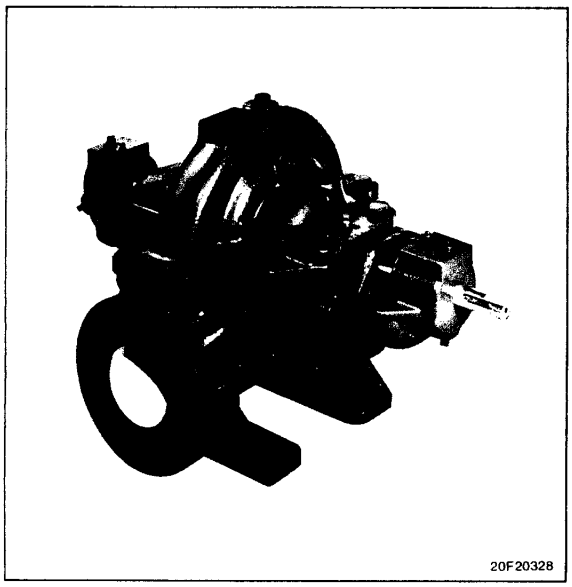
The model LLR, single-suction, two-stage designs are available in 1½-4" sizes. They feature two single-suction impellers placed back-to-back to minimize axial thrust. Radial thrust is balanced through the use of opposed volutes. Impellers are firmly secured to the shaft by use of a key and nut.

Typical industries served.

☐ process	☐ steel	☐ pharmaceutical
☐ building trades	☐ sugar	☐ pipeline
☐ O.E.M.	☐ utilities	☐ agriculture
☐ food	☐ public works	☐ pulp and paper
☐ mining	☐ petroleum	☐ rubber

TYPE LR

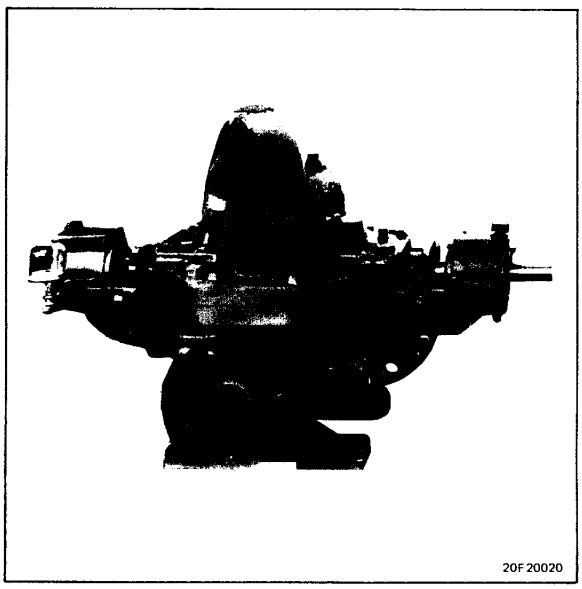
Sizes: 2½ to 16" **Heads:** to 560'
Capacities: To 20,000 gpm **Temperatures:** To 300°F



20F20328

TYPE LLR

Sizes: 1½" to 4" **Heads:** to 1,000'
Capacities: To 1300 gpm **Temperatures:** To 300°F



20F20020

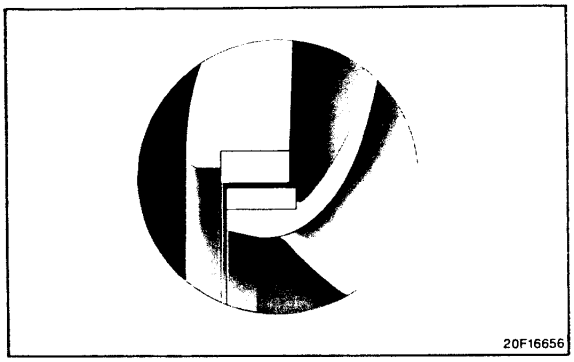
A unique combination of design features leads to higher efficiencies and lower maintenance requirements

Closed impellers mean high efficiency.

Highly efficient closed impellers mean energy savings for you. All closed impellers are hydraulically balanced to further reduce bearing loads. Experience and research has shown that closed impellers retain their efficiency longer. Closed impellers also offer inherently greater axial hydraulic balance minimizing thrust loads, resulting in longer bearing life.

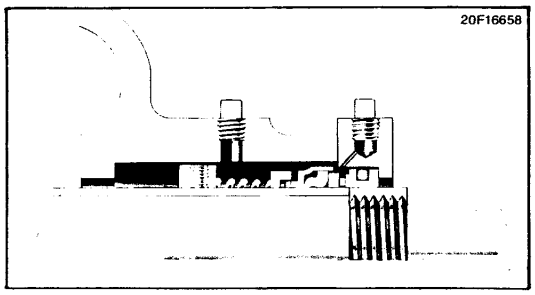
Wear rings designed for easy replacement.

Case wearing rings protect the pump casing from needless wear. They are renewable and held in place by monel pins to protect against rotation. Designed for quick and easy replacement to reduce maintenance downtime and costs, the wear rings are less complex than other designs and employ a simple, heavy-cross section rectangular design for positive fit.



Stuffing box designed for long packing/seal life.

Because seals or packing are adjacent to the suction side of the impeller, they are sealing against the lowest pressure available. The conventional type stuffing box is easily converted for use with packing or mechanical seal.

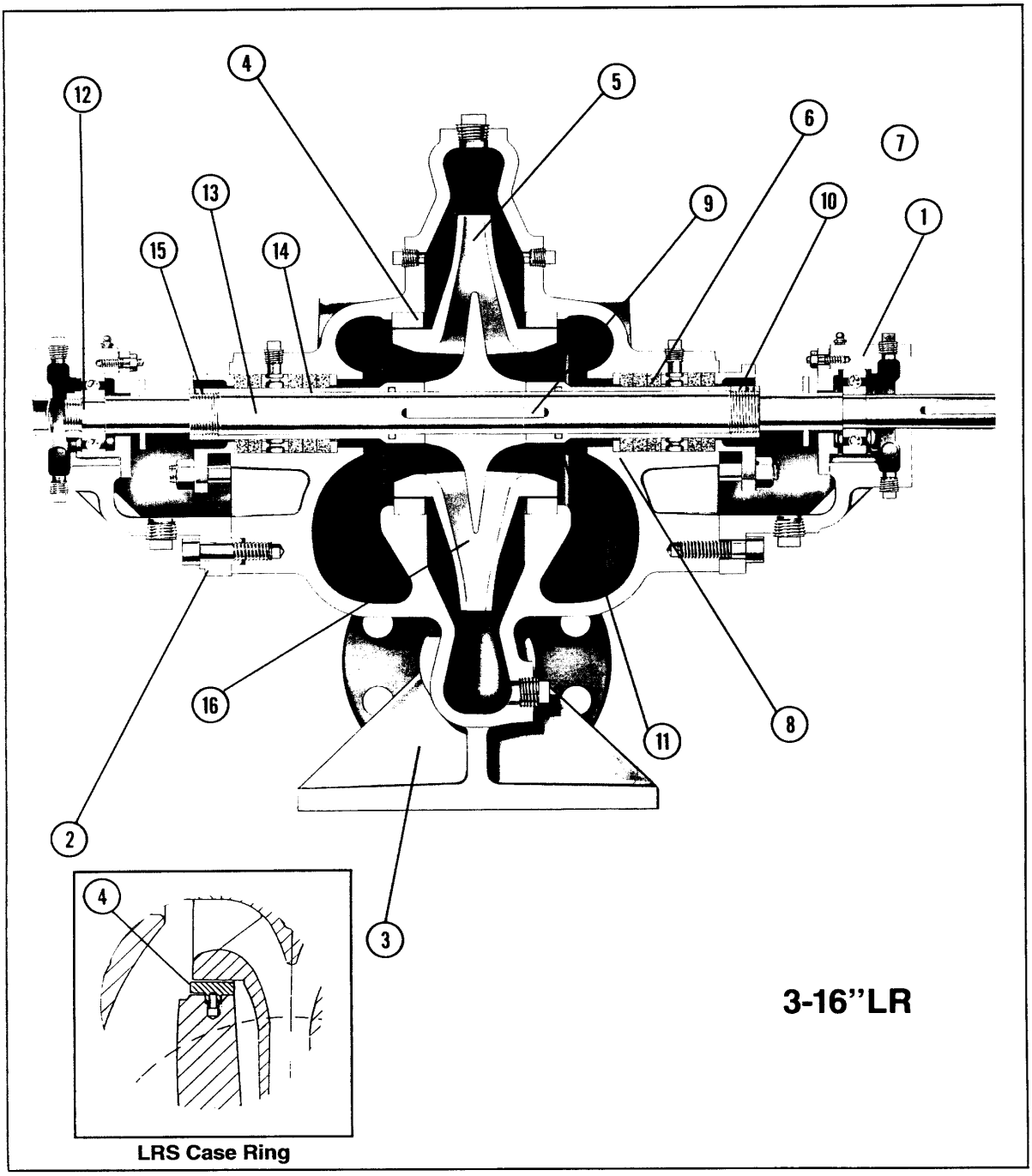


More ease of maintenance features.

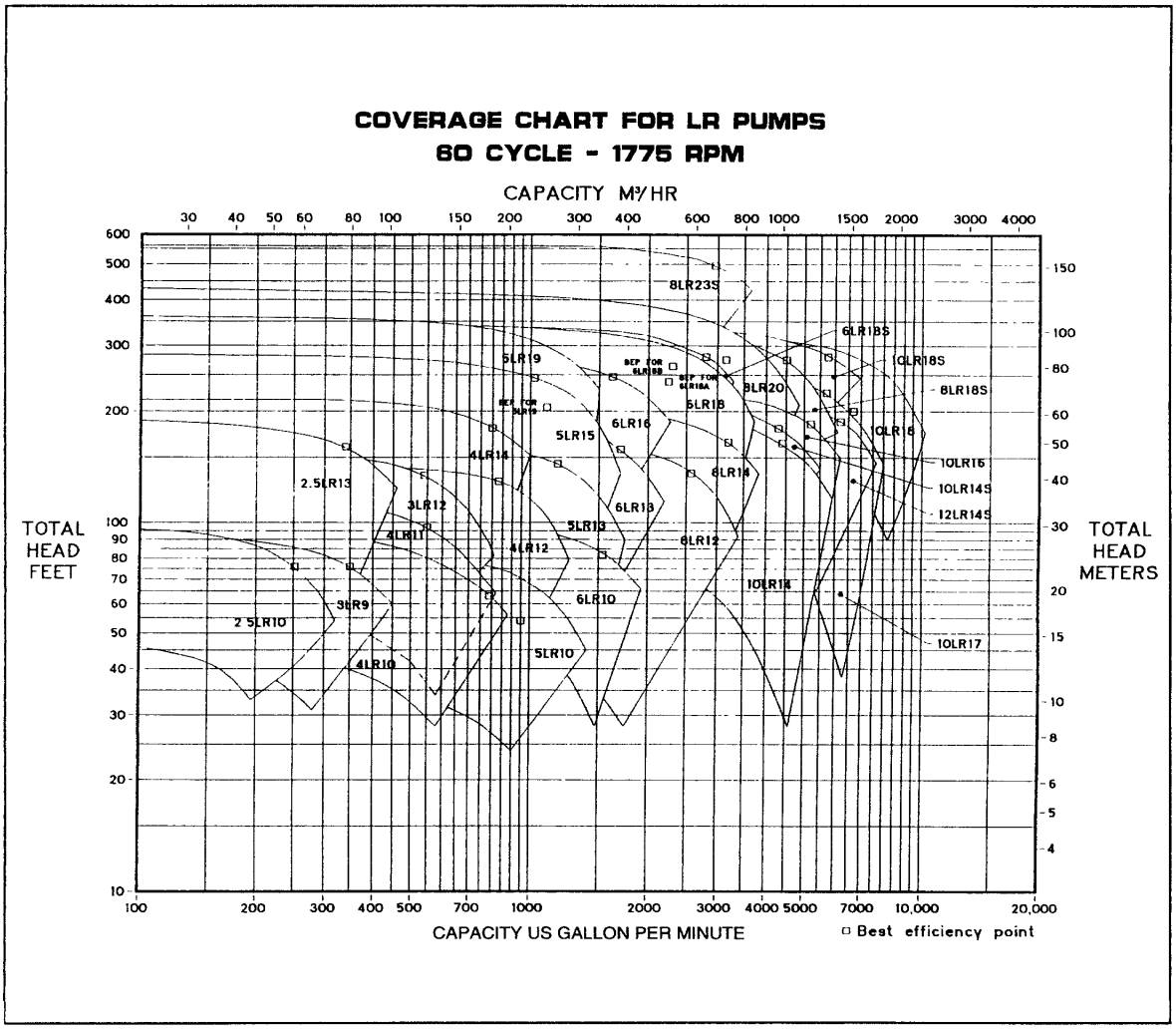
Maintenance time costs money in labor, parts and reduced production. Check these additional features designed to reduce periodic and unscheduled downtime:

- ☐ Removable, replaceable stuffing box bushing to ensure proper packing position.
- ☐ Wide range of construction materials to meet conditions of service and thus contribute to lower operating and maintenance costs.
- ☐ Shaft-sleeve nuts set-screwed to shaft prevent nuts from loosening. Also, location exterior to stuffing box allows visibility to assure maintenance of impeller positioning.
- ☐ Impeller supported between bearings, rather than overhung like an end-suction centrifugal, reduces bearing load and increases life.
- ☐ The removable bearing bracket design also achieves a shorter distance between bearings which provides a more rigid shaft — resulting in less shaft deflection.

Designs and sizes available to meet your specific application requirements

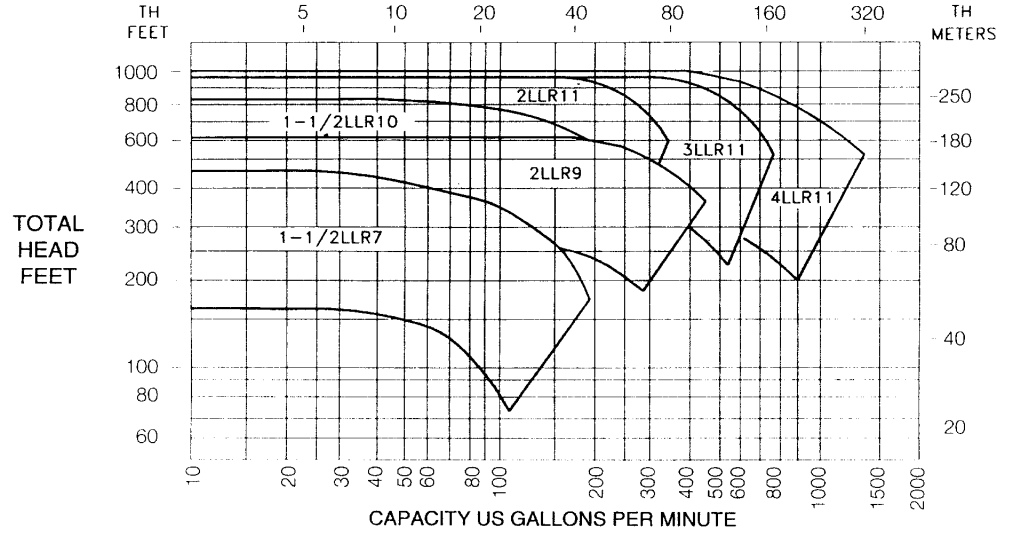


Extensive coverage for better selection at any design point



COVERAGE CHART FOR LLR PUMPS

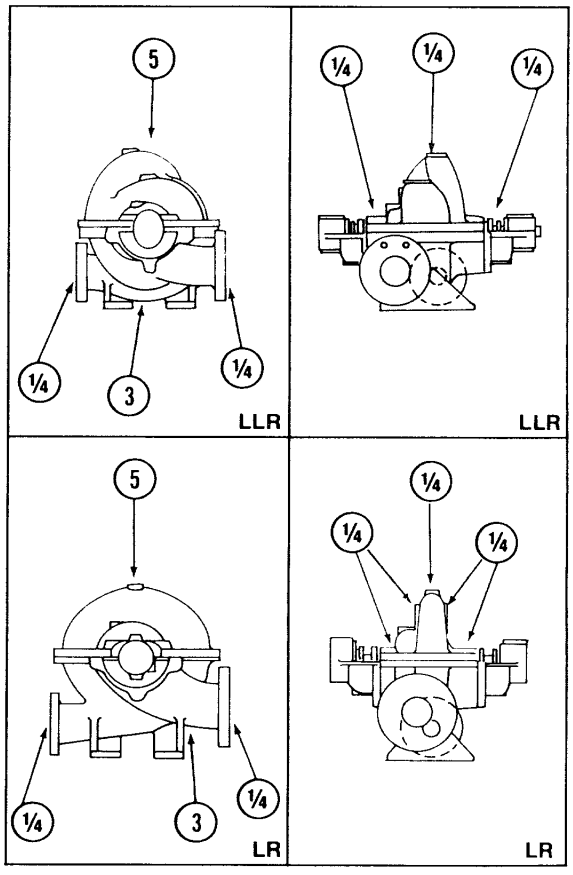
3600 RPM – 60 CYCLE



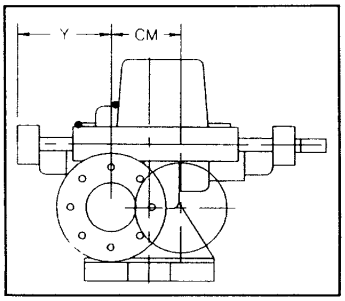
NPT Connections

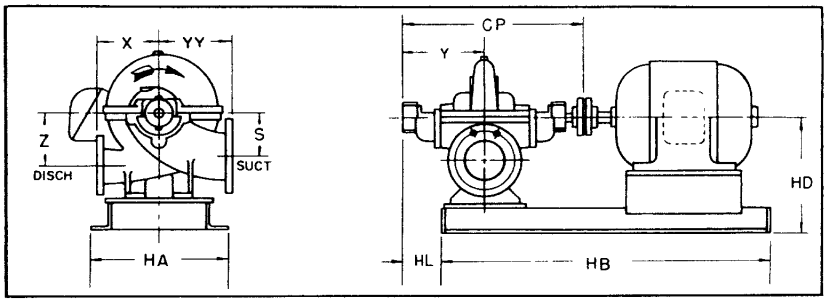
	CASING CONNECTIONS	
PUMP SIZE	3	5
1½ LLR 7	1/2	1/2
1½ LLR 10	1/2	1/2
2 LLR 9	1/2	1/2
2 LLR 11	1/2	1/2
3 LLR 11	1/2	1/2
4 LLR 11	1/2	1/2
2½ LR 10	1/2	1/2
2½ LR 13	1/2	1/2
3 LR 9	1/2	1/2
3 LR 12	1/2	1/2
4 LR 10	1/2	1/2
4 LR 11	1/2	1/2
4 LR 12	1/2	1/2
4 LR 14	1/2	1/2
5 LR 10	1/2	1/2
5 LR 13	1/2	1/2
5 LR 15	1/2	1/2
5 LR 19	1/2	1/2
6 LR 10	1/2	1/2
6 LR 13	1/2	1/2
6 LR 16	1/2	1/2
6 LR 18	3/4	3/4
6 LR 18S	3/4	3/4
8 LR 12	1/2	1/2
8 LR 14	1/2	1/2
8 LR 18S	3/4	3/4
8 LR 23S	3/4	3/4
10 LR 14	3/4	3/4
10 LR 14S	3/4	3/4
10 LR 16	3/4	3/4
10 LR 18S	3/4	3/4
12 LR 14S	3/4	3/4
8 LR 20	1	3/4
10 LR 17	1	3/4
10 LR 18	1	3/4
12 LR 17	3/4	3/4
12 LR 25	3/4	3/4
16 LR 18	3/4	3/4
16 LR 20	3/4	3/4

3 Casing Drain 5 Vent Connection



Dimensions





PUMP DIMENSIONS

PUMP SIZE	SUCT.	DISCH.	S	X	Y	Z	CP	CM	YY	HD	HL	WT	BASE
1½ LLR 7	2	1 1/2	3 1/2	6 3/4	9 3/4	4 3/4	26 3/4	3 1/4	6 3/4	12 1/2	4	200	1
1½ LLR 10	3	1 1/2	4 1/4	8½	10 1/2	5 1/4	26 3/4	4	8 1/2	13 1/4	4	360	1
2 LLR 9	3	2	4 1/4	8	10 7/8	5	26 3/4	4 1/2	8 3/8	13 1/4	4	290	1
2 LLR 11	3	2	4 1/4	9 3/4	12 7/16	6	37	4 15/16	10	19 1/4	10 3/16	520	5
3 LLR 11	4	3	5 1/4	10	11 13/16	6 1/2	37	5 11/16	10 1/2	21 3/8	8 11/16	625	5
4 LLR 11	6	1 1/2	6 1/2	10	11 7/16	7 1/4	37	6 3/16	11 1/2	24 13/16	8 11/16	730	5
2½ LR 10	3	2 1/2	5	8	10 1/4	6 1/2	23	1 1/2	8 3/4	15	6	220	1
2½ LR 13	4	2 1/2	5 3/4	9 1/2	11 1/8	7 1/2	24 5/8	1 1/2	10	16	7	250	1
3 LR 9	4	3	5 1/4	7 1/2	12	5 3/4	26 3/4	-	9	16	6 1/4	220	1
3 LR 12	5	3	5 3/4	8 3/8	12	7 1/4	26 3/4	-	10 1/2	16	6 1/4	280	1
4 LR 10	5	4	5 3/4	9	12	6 1/4	26 3/4	-	11	17 1/2	6 1/4	280	1
4 LR 11	6	4	6 3/8	10	13	6 1/2	30	-	12 1/2	17 1/2	6	320	2
4 LR 12	6	4	6 3/8	9	12 1/4	7 3/4	27	-	11	17 1/2	6	400	1
4 LR 14	6	4	6 3/8	12	13	7 5/8	30	-	12 1/2	17 1/2	6	385	2
5 LR 10	6	5	6 1/2	9 1/2	12 1/4	7	27	-	13	17 1/2	6	370	2
5 LR 13	6	5	6 1/2	10 1/2	13	7 1/4	30	-	13	17 1/2	6	425	2
5 LR 15	6	5	6 1/2	13	14 3/4	7 1/4	34	-	13 1/2	17 1/2	7 3/4	600	1
5 LR 19	6	5	7 7/8	12 1/2	14 3/4	10 1/2	34	-	15 3/4	15 3/4	9 1/2	800	5
6 LR 10	8	6	7 3/4	10	13	7 1/4	28 1/8	-	14	14	6	425	2
6 LR 13	8	6	7 1/2	11	14 3/4	9	34	-	14	14	7 3/4	610	1
6 LR 16	8	6	7 5/8	14	14 3/4	8 1/2	34	-	15	15	7 3/4	680	1
6 LR 18	10	6	9	12 1/2	17 1/4	10 1/2	39	-	17	17	12	1000	3
6 LR 18S	10	6	12	17	17 1/16	12 1/4	39 1/8	-	20	26	-	1349	6
8 LR 12	10	8	8 7/8	11 1/4	17 1/4	10	34	-	17	24 1/4	7 3/4	780	1
8 LR 14	10	8	8 7/8	11 1/4	17 1/4	10	34	-	17	24 1/4	12	780	1
8 LR 18S	12	8	13	19	20	12 1/2	46	-	22	28	-	1677	6
8 LR 23S	10	8	12	19	20	15 1/2	46	-	27	28	-	2400	6
10 LR 14	12	10	10 1/2	14	17 1/4	10 1/2	39	-	18	27 3/4	12	1185	3
10 LR 14S	12	10	13	20	20 1/16	11 1/2	44 3/8	-	22	28	-	1551	6
10 LR 16	12	10	10 1/2	14	17 1/4	10 1/2	39	-	18	27 3/4	12	1185	3
10 LR 18S	14	10	14	20	20	13 1/2	46	-	26	30	-	2045	6
12 LR 14S	14	12	14	22	20 1/16	12 3/4	44 3/8	-	26	30	-	1892	6
8 LR 20	12	8	10 1/2	14 1/2	17 1/4	13 1/4	39	-	18	27 3/4	12	1059	3
10 LR 17	14	10	12	16	19 1/8	13 1/4	45 1/8	-	19 1/2	30	8 3/4	1500	4
10 LR 18	14	10	12	16	19 1/8	13 1/4	45 1/8	-	19 1/2	30	8 3/4	1500	4
12 LR 17	18	12	16	20	23	16	50 1/4	-	26	-	-	1800	-
12 LR 25	18	12	14 1/2	21	23 9/16	18	54 1/10	-	24 3/4	-	-	3200	-
16 LR 18	20	16	18	22	24 5/8	18	56	-	28	-	-	4000	-
16 LR 20	24	16	20	24	27 3/4	20	62 9/20	-	32	-	-	4400	-

BASE DIMENSIONS

NEMA	BASE 1			BASE 2			BASE 3			BASE 4			BASE 5			BASE 6		
Motor Frame	HA	HB	WT (Base)	HA	HB	WT (Base)	HA	HB	WT (Base)	HA	HB	WT (Base)	HA	HB	WT (Base)	HA	HB	WT (Base)
182T	24	41 3/4	210	24	41 3/4	210	-	-	-	-	-	-	-	-	-	-	-	-
184T	24	41 3/4	210	24	41 3/4	210	-	-	-	-	-	-	24	54 1/2	230	-	-	-
213T	24	41 3/4	210	24	41 3/4	210	-	-	-	-	-	-	24	54 1/2	230	-	-	-
215T	24	41 3/4	210	24	41 3/4	210	-	-	-	-	-	-	24	54 1/2	230	-	-	-
254T	24	41 3/4	210	24	54 1/2	230	-	-	-	-	-	-	24	54 1/2	230	-	-	-
256T	24	41 3/4	210	24	54 1/2	230	-	-	-	-	-	-	24	54 1/2	230	-	-	-
284T	24	54 1/2	230	24	54 1/2	230	-	-	-	-	-	-	28	60	410	-	-	-
286T	24	54 1/2	230	24	54 1/2	230	28	60	410	-	-	-	28	60	410	-	-	-
324T	24	54 1/2	230	24	54 1/2	230	28	60	410	-	-	-	28	60	410	-	-	-
326T	24	54 1/2	230	24	54 1/2	230	28	60	410	-	-	-	28	60	410	-	-	-
364T	24	54 1/2	230	24	54 1/2	230	28	60	410	-	-	-	32	72	600	-	-	-
365T	24	54 1/2	230	24	54 1/2	230	28	60	410	-	-	-	32	72	600	-	-	-
404T	24	64 1/4	250	24	54 1/2	230	32	66	510	32	72	600	32	72	600	24	80	306
405T	24	64 1/4	250	24	54 1/2	230	32	66	510	32	72	600	32	72	600	24	80	306
444T	24	64 1/4	250	24	64 1/4	250	32	66	510	32	72	600	32	84	640	24	80	306
445T	24	64 1/4	250	24	64 1/4	250	32	66	510	32	84	640	32	84	640	24	88	351
447T	-	-	-	-	-	-	-	-	-	32	84	640	32	84	640	24	88	351
449T	-	-	-	-	-	-	-	-	-	32	84	640	32	84	640	24	88	351

Baseplate dimensions will vary slightly with motor frame size. All dimensions are in inches, are approximate, and are not to be used for construction purposes.

Typical specifications

1. Casing

The casing shall be of the volute type and designed to produce a smooth flow with gradual changes in velocity. The casing shall be split on the horizontal center line with the suction and discharge nozzles and casing feet cast integrally with the lower casing half. The interior of the pump shall be easily inspected by removing the upper half of the casing. This shall be done without disturbing the pipe connections or pump alignment. The flanges between the halves will be sealed by a pre-cut gasket. The upper and lower halves of the casing shall be accurately located by the use of straight dowel pins to eliminate mismatch between the upper and lower halves which would impair both hydraulic and mechanical performance. The casing shall be hydrotested to one and one half times the working pressure; suction and discharge flanges shall contain drilled and tapped gage connections. The casing shall be single volute type. (The 4LR-11, 6LR-18, 6LR-18S, 8LR-12, 8LR-14, 8LR-18S, 8LR-20, 8LR-23S, 10LR-14, 10LR-14S, 10LR-16, 10LR-17, 10LR-18, 10LR-18S, 12LR-14S, 12LR-17, 12LR-25, 16LR-18, and 16LR-20 shall be twin-volute type.)
LLR — On two-stage pumps the casing tongues shall be spaced 180 degrees apart, balancing radial loads. The crossover shall be cast in the upper half of the casing, affording an inherently rigid design necessary for high pressure applications.

2. Impeller

The impeller shall be double-suction enclosed type. (The 2½LR-10 and 2½LR-13 shall be single-suction enclosed type.) It shall be hydraulically balanced by its inherent design. The impeller shall be firmly secured to the shaft by a key positioned by shaft sleeves and both locked in place by shaft sleeve locknuts external to the stuffing box.
LLR — Two single-suction impellers shall be placed back to back to eliminate axial thrust. They shall be firmly secured to the shaft by a key positioned by shaft sleeves and both locked in place by shaft sleeve locknuts external to the stuffing box.

3. Renewable Casing Wear Rings

Renewable casing wear rings shall be locked in place and protected against rotation by corrosion resistant pins. **Impeller Wear Rings** — Securely held impeller wear rings can be supplied as an option.

4. Stuffing Box Bushing

Pump casing shall have a renewable stuffing box throat bushing.

5. Shaft Sleeve

Renewable shaft sleeves shall be provided which extend through stuffing box. They shall be securely keyed and held in place with shaft nuts incorporating set screws for locking purposes. Sealing to protect against leakage under the shaft sleeves shall be with "O" rings at the shaft outer diameter.

LLR - Will additionally have gaskets between the shaft sleeve and impeller.

6. Shaft

The shaft shall be heat-treated steel, machined to accurate dimensions and polished to a smooth surface. The shaft shall have the same nominal diameter from one shaft sleeve locknut to the other to minimize fatigue failure due to stress concentration. The shaft sleeves shall protect the shaft at the stuffing boxes. The sleeves shall be secured in a lateral position by external shaft nuts. The impeller keys shall extend into the hub of the shaft sleeves. The shaft shall be adequately sized and designed to minimize deflection. The maximum shaft deflection at the stuffing box face shall not exceed .002" at 25% of BEP.

7. Bearings

The bearings shall be single row, deep-groove type ball bearings. They shall be designed and sized for at least 100,000 hours calculated minimum B10 rated bearing life at 25% BEP per ANSI B 3.15. Each bearing shall be capable of carrying both line and thrust type loads. The thrust bearing shall be securely held to the shaft.

LLR — Angular contact thrust bearing placed back to back shall be furnished on one end.

8. Bearing Brackets

The bearing brackets shall be separate from the pump casing and accurately machined and doweled to the casing. Oil or grease lubrication shall be provided. Grease gun fittings shall be standard on grease-lubricated pumps and a constant-level oiler shall be standard on oil lubricated pumps. Pump design shall allow the bearing to be removed without disturbing upper casing for inspection and replacement of the bearings, mechanical seals and shaft sleeves.

9. Packing-Mechanical Seals

As a standard, stuffing boxes shall be packed with the best quality graphite impregnated non-asbestos packing. Die-molded packing shall be supplied to insure both a thorough seal and an easy installation. Mechanical seals shall be easily interchangeable with packing.

10. Spacer Sleeve (LLR Only)

A securely keyed spacer sleeve shall be provided to accurately position the impellers. The inter-stage bushing shall be held securely by a monel set screw. The spacer sleeve shall be sealed against leakage with gaskets between the impellers and spacer sleeve. Both sleeve and bushing shall be easily replaced to restore original clearances.

11. Casing Feet

The casing feet shall be integrally cast with the lower casing and be immediately adjacent to suction and discharge flanges in order to transmit any pipe strain loads to the base and foundation.

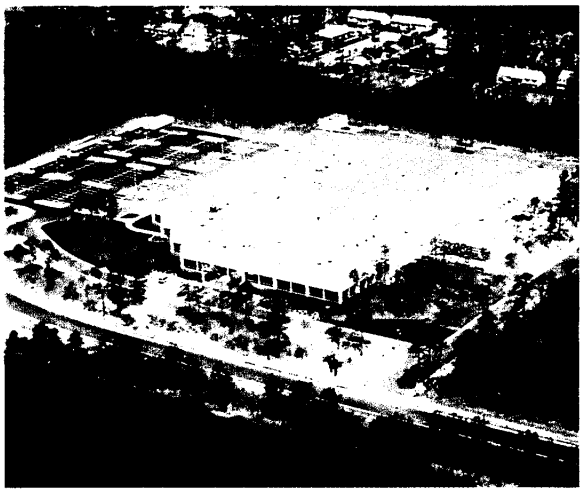
Worldwide distribution assures availability of pumps, parts, and service

Our extensive network of Ingersoll-Dresser Pump sales offices and Ingersoll-Dresser Pump distributors, located in every major trading area, is your assurance that there is a representative nearby whenever you need prompt local service.

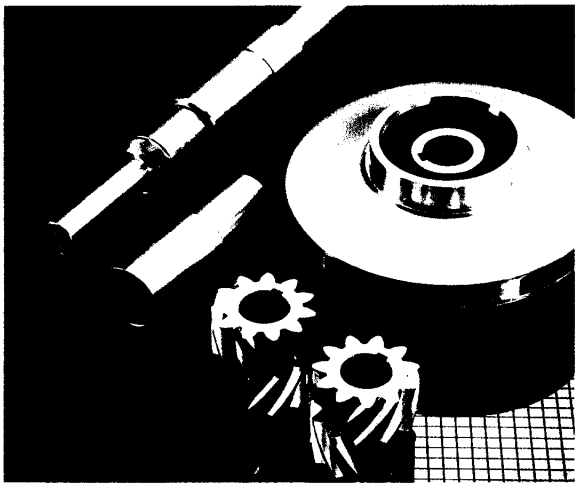
Ingersoll-Dresser Pump distributors are factory-trained specialists in pumping equipment. They can offer you expert assistance on pump application, selection, installation, operation, and maintenance.

Local availability is another benefit of selecting and using Ingersoll-Dresser pumps. Ingersoll-Dresser Pump distributors carry large inventories of pumps and parts. In most cases, immediate shipment can be assured. And service is always nearby for prompt reaction to your specific needs.

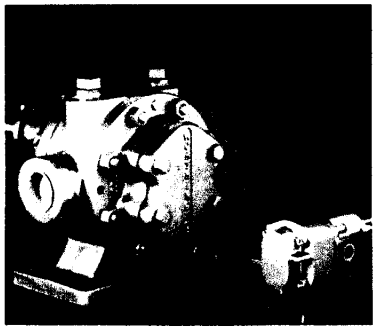
Check the Yellow Pages of your local telephone directory to find the Ingersoll-Dresser Pump sales office or Ingersoll-Dresser Pump distributor in your area.



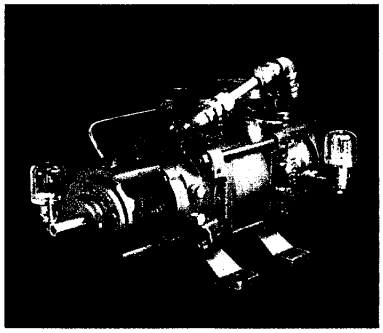
At our modern production facilities, we manufacture our pumps to the highest standards of quality.



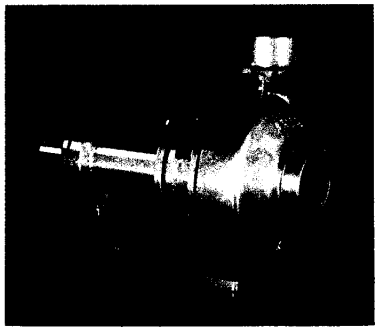
Our quality parts and service provide you with the best product for your needs.



GR/GA Rotary Gear Pumps



WD Multistage Pump

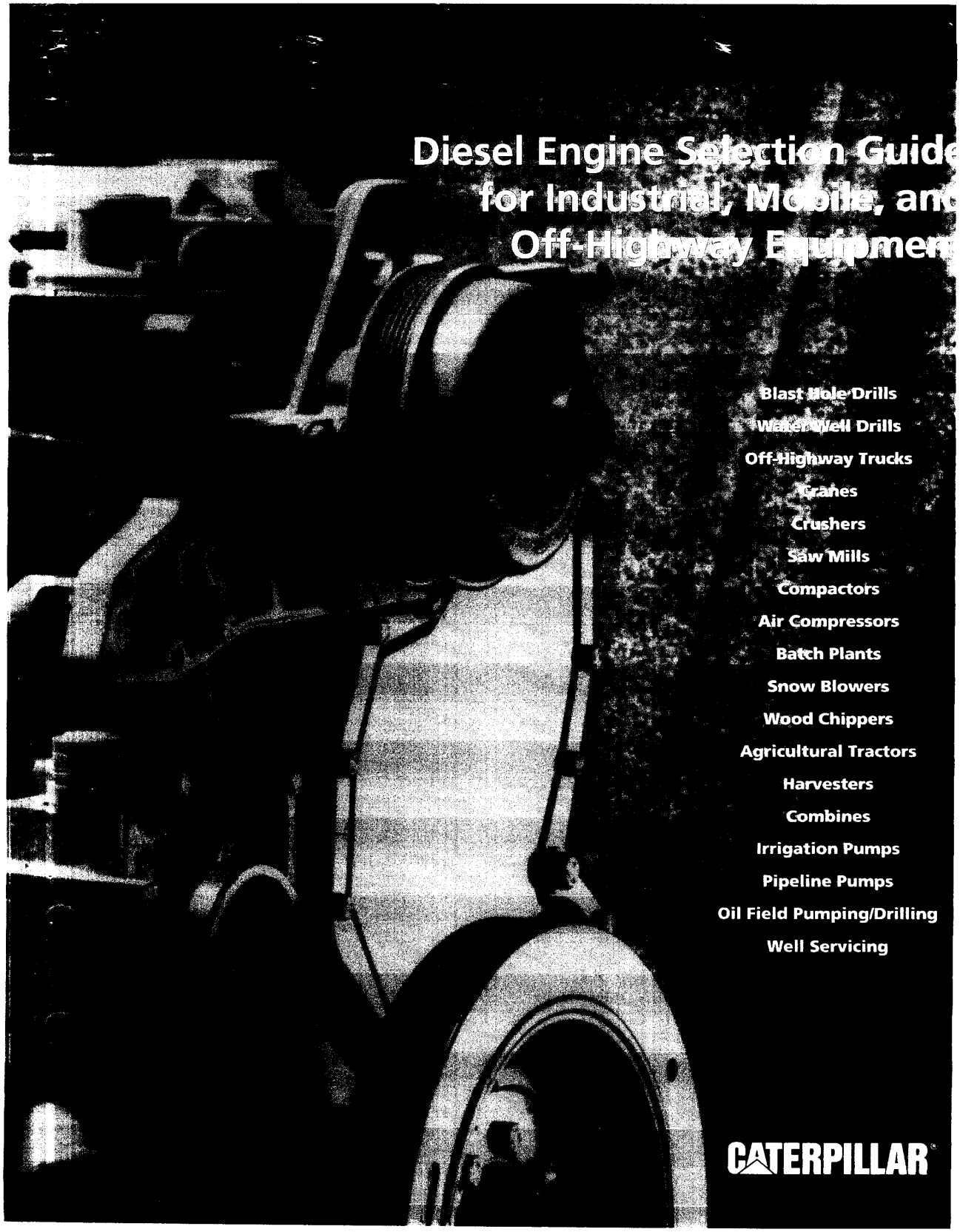


D-800 End Suction Pump

Your local contact is:

INGERSOLL-DRESSER PUMP COMPANY
3900 Cook Boulevard
Chesapeake, Va 23323-1626

Ingersoll-Dresser Pump Company



Diesel Engine Selection Guide for Industrial, Mobile, and Off-Highway Equipment

- Blast Hole Drills
- Water Well Drills
- Off-Highway Trucks
- Cranes
- Crushers
- Saw Mills
- Compactors
- Air Compressors
- Batch Plants
- Snow Blowers
- Wood Chippers
- Agricultural Tractors
- Harvesters
- Combines
- Irrigation Pumps
- Pipeline Pumps
- Oil Field Pumping/Drilling
- Well Servicing

CATERPILLAR®

Now you can specify power better matched to your specific application need.
76-6600 hp (56 to 4920 kW)

Take advantage of a new, wider range of power ratings based on specific types of application and operation. The wider range of ratings enables you to purchase only the power needed and possibly a smaller, less costly engine.

But regardless of the rating or engine specified, count on superior reliability. It is a top design objective for every engine. And to make sure our finished product meets this goal, we subject regular-production engines to hundreds of difficult tests.

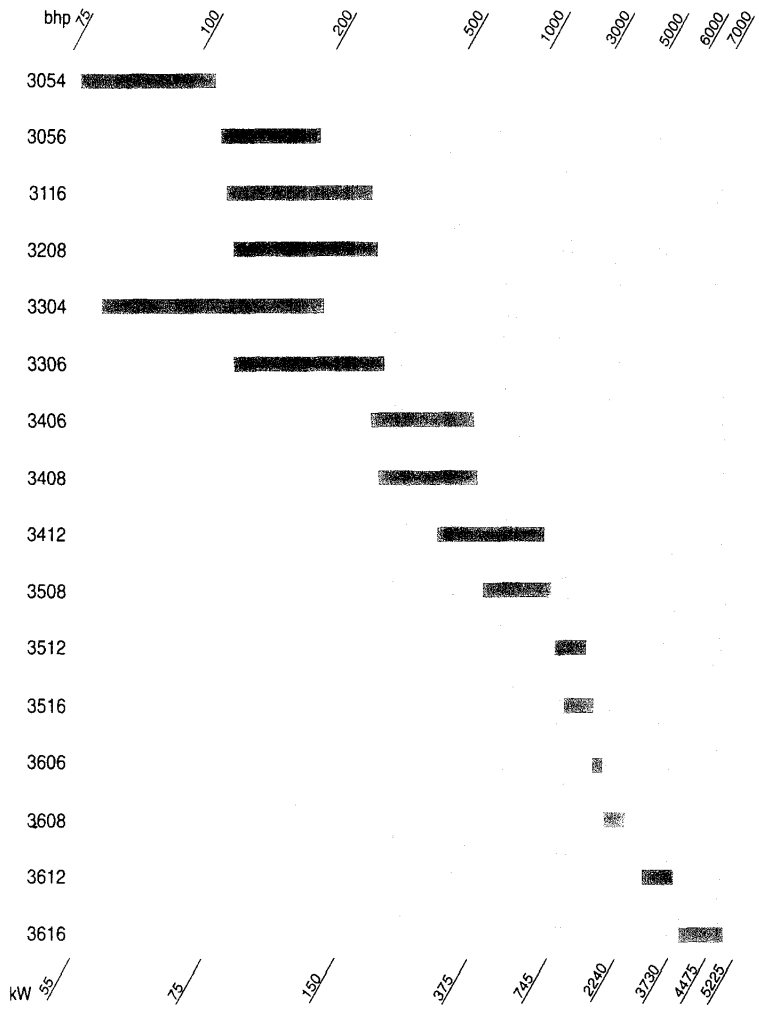
One is a thermal cycle test. Engines are superheated to scalding, then quickly cooled to ambient air temperature. Then we do it 3,999 more times. Only if it's unaffected by that type of thermal stress does the engine pass.

In our cyclic load test, we simulate the toughest strain cycles an engine will be called upon to survive. For thousands of hours, we alternate between full load at rated speed and maximum output at peak torque. Count on Cat engines to keep working under your most demanding conditions.

The chart on the next page will help you identify the best candidates for your applications. Detailed features and data are provided on the following pages.

CATERPILLAR ENGINE FACILITIES ISO 9001 CERTIFIED

Match a Reliable Cat® Diesel to Your Application.



Abbreviations used in this bulletin:

NA – Naturally aspirated
T – Turbocharged
TA – Turbocharged-aftercooled
bhp – Brake horsepower
kW – Metric equivalent of horsepower
DI – Direct injection
PC – Precombustion chamber

Explanation of Ratings A, B, C, D, E.
Note: Application examples are for reference only. For an exact determination of the appropriate rating, contact the factory or your local Caterpillar Dealer.

A Rating (Continuous):
- For heavy-duty services when engine is operated at rated load and speed up to 100% of the time without interruption or load cycling.
- Time at full load up to 100% of the duty cycle.
- Typical application examples include pipeline pumping, ventilation.

B Rating:
- For service where power and/or speed are cyclic.
- Time at full load not to exceed 80% of the duty cycle.
- Typical application examples include irrigation where normal pump demand is 85% of engine rating, oil field mechanical pumping/drilling, stationary/plant air compressors.

C Rating (Intermittent):
- For service where power and/or speed are cyclic. Horsepower and speed capability of the engine can be utilized for one uninterrupted hour followed by one hour of operation at or below the A rating.
- Time at full load not to exceed 50% of the duty cycle.
- Typical application examples include agricultural tractors, harvesters and combines, truck off-highway, fire pumps, blast hole drills, rock crushers, wood chippers with high torque rise, and oil field hoisting.

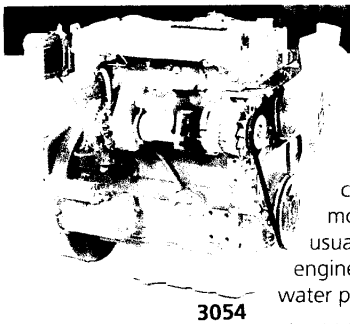
D Rating:
- For service where rated power is required for periodic overloads. The maximum horsepower and speed capability of the engine can be utilized for a maximum of 30 uninterrupted minutes followed by one hour at the C rating.
- Time at full load not to exceed 10% of the duty cycle.
- Typical application examples include offshore cranes, runway snow blowers, water well drills, portable air compressors, and fire pump certification power.

E Rating:
- For service where rated power is required for a short time for initial starting or sudden overload. For emergency service where standard power is unavailable. Horsepower and speed capability of the engine can be utilized for a maximum of 15 uninterrupted minutes followed by one hour at the C rating or duration of emergency.
- Time at full load not to exceed 5% of the duty cycle.
- Typical application examples include standby centrifugal water pumps, oil field well servicing, crash trucks, and gas turbine starters.

Rating conditions:
All ratings are based on SAE J1349 standard ambient conditions of 29.6 in Hg (100 kPa), 30% relative humidity and 77°F (25°C). Ratings also apply at AS1501, BS5514, DIN6271 and ISO3046/1 standard conditions.

Power is based on API gravity of 35 at 60°F (15°C), fuel having a LHV of 18,390 Btu/lb (42 780 kJ/kg) used at 84°F (29°C) with a density of 7.001 lb/U.S. gal (838.9 g/L).

Ratings are the total output capability of the engine equipped with standard accessories: lube oil, fuel oil



3054

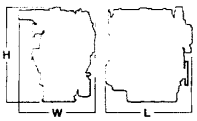
Our newest design, these 1.0-liter-per cylinder, direct injection models incorporate features usually found only on larger engines, like the gear-driven water pump.

The 3054 and 3056 use precision-honed, field-replaceable dry cylinder liners. Besides providing excellent oil control, they can be removed and installed easily at rebuild time. Because they're dry, you'll never face coolant joints leaks.

The lubrication system is powered by a pan-mounted oil pump, gear driven directly off the crankshaft. The gerator pump delivers oil directly to the main oil gallery on its way to the turbo and main bearings. Because it's mounted below the crankshaft centerline, the pump primes quickly and gets up to pressure fast, minimizing wear.

Models are available in three arrangements: a basic industrial engine (without fan, fan drive, starter or alternator), an industrial fan-to-flywheel arrangement (which includes a fan, fan drive, starter and alternator), and an industrial power unit (which adds an engine-mounted air filter, radiator, fan guard and pedestal engine mounts). A power takeoff on the left side of the engine drives off the idler in the front gear train.

The engines' superior torque characteristics give you smooth, dependable performance. The proven Caterpillar serviced fuel system can be counted on to deliver full-rated power through years of service, without periodic adjustment or maintenance. Fuel efficiency is excellent regardless of the application or load characteristics. And exhaust emissions and noise levels are low enough to meet some of the toughest standards in the world.



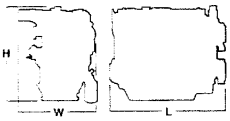
3054 In-Line 4

Bore x Stroke	3.937 x 5.0 in	100 x 127 mm
Displacement	243 cu in	4.0 liters
Ship Weight (NA)	600 lb	273 kg

Approximate Dimensions:

Length*	27 in	693 mm
Width	24 in	610 mm
Height	31 in	780 mm

	A Rating (Continuous)			C Rating (Intermittent)		
	bhp	**kW**	**rpm**	**bhp**	**kW**	**rpm**
DINA	76	56	2400	87	65	2600
DIT	96	72	2400	111	83	2600



3056 In-Line 6

Bore x Stroke	3.937 x 5.0 in	100 x 127 mm
Displacement	365 cu in	6.0 liters
Ship Weight (NA)	902 lb	410 kg

Approximate Dimensions:

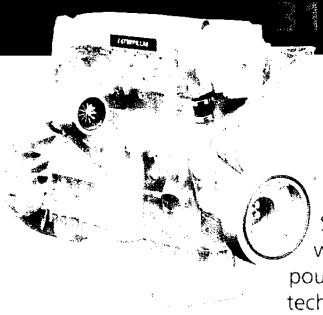
Length*	37 in	927 mm
Width	25 in	632 mm
Height	32 in	801 mm

	A Rating (Continuous)			C Rating (Intermittent)		
	bhp	**kW**	**rpm**	**bhp**	**kW**	**rpm**
DINA	114	84	2400	129	96	2600
DIT	140	105	2400	159	119	2600
DITA	160	119	2400	181	135	2600

* Length: from rear surface of crankshaft to front surface of water pump housing.

Note: For accurate dimensions consult your Cat representative.

3116 Engine



3116

Not long ago, diesel engines weighed about 10 pounds per horsepower. So a typical 270 hp engine weighed about 2,700 pounds. Today Caterpillar technology squeezes similar horsepower into less than 1,200 lb of engine.

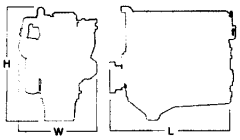
With these smaller, lighter frame structures and mounting systems, equipment manufacturers enjoy greater design flexibility. The 3116 offers three flywheel housings, two turbocharger locations, four in-block dipstick locations, and four oil pan configurations. You also get optional oil filler locations, a single-belt water pump drive, right-hand starter, and a 60 hp (45 kW) gear-driven power takeoff capability.

This weight reduction, without sacrificing durability and reliability, has resulted largely from a simpler design and smarter manufacturing. For example, most fuel, oil and water lines are integrated into the head and block.

Intake and exhaust manifolds are on the same side of the block. That way, crossover pipes are eliminated and top-end service is easier. The oil pump and air compressor are gear-driven, s you don't face broken belts a periodic replacement. Four massive head bolts per cylind acting through ribs in the blc assure firing loads are transmitted to the strongest portion of the block.

The water pump and fan are located outside the block for service access and extended service life. Camshaft bearin valve guides and valve inserts replaceable. The 3116 can b rebored; dry sleeves are avail

Choose the 3116 that best meets your needs, and get th power of a heavyweight in a lightweight size.

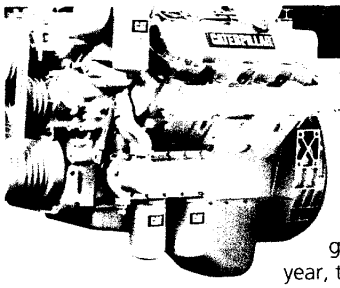


3116 In-Line 6

Bore x Stroke	4.12 x 5.0 in	105 x 127 mm	**Approximate Dimensions (T):**
Displacement	403 cu in	6.6 liters	Length, from damper to rear face* 38 in 967 mm
Ship Weight (T)	1085 lb	493 kg	Width 26 in 650 mm
			Height 36 in 925 mm

	A Rating (Continuous)			B Rating			C Rating (Intermittent)			D Rating			E Rating		
	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm
DIT (L)	–	–	–	115	86	1800	–	–	–	–	–	–	–	–	–
(L)	130	97	2200	140	105	2200	145	108	2200	160	119	2200	160	119	2200
(L)	140	104	2400	150	112	2400	155	116	2400	165	123	2400	165	123	2400
(L)	–	–	–	–	–	–	170	127	2600	180	134	2600	180	134	2600
DITA (M)	–	–	–	130	97	1800	–	–	–	–	–	–	–	–	–
(M)	140	104	2200	150	112	2200	160	119	2200	195	146	2200	225	168	2200
(M)	150	112	2400	165	123	2400	175	131	2400	210	157	2400	220	164	2400
(M)	–	–	–	–	–	–	190	142	2600	190	142	2600	190	142	2600
DITA (H)	–	–	–	160	119	1800	–	–	–	–	–	–	–	–	–
(H)	175	131	2200	185	138	2200	195	145	2200	220	164	2200	220	164	2200
(H)	190	142	2400	200	149	2400	210	157	2400	230	172	2400	230	172	2400
(H)	–	–	–	–	–	–	230	172	2600	240	179	2600	240	179	2600
(H)	–	–	–	–	–	–	260	194	2600	270	201	2600	270	201	2600

(L) Low ratings – one-piece aluminum piston
(M) Medium ratings – one-piece aluminum piston
(H) High ratings – two-piece controlled expansion piston
* Length from damper to the rear face of the cylinder block. SAE #1, 2 or 3 flywheel housings are attachments.



3208

Caterpillar has built close to a half million 3208s over the last 20+ years. Most are still going strong. And every year, thousands of new ones go to work. More importantly, they have been regularly and systematically improved. The 3208 you buy today is even more dependable and reliable than its proven predecessor.

The 3208's displacement, largest in its class, results in exceptional responsiveness. The power is there quickly to meet rising demand. And it stays up under high demand.

We designed the engine to need little attention. The Caterpillar fuel system is a good example. It requires no adjustments and never needs calibrating or balancing. You can change fuel nozzles in the field, almost as easily as a gasoline engine's spark plugs.

Should a fuel pump go out, you can replace it without setting it or adjusting it to match the other pumps. And the entire system is rebuildable.

Designed for Repeat Performance.

At overhaul, more than 60% of the 3208's original parts are typically reusable.

That means you can expect them to perform to full factory specs until the next overhaul. The "reusable" list includes pistons, rods, crankshafts, fuel and water pumps, turbochargers and heads.

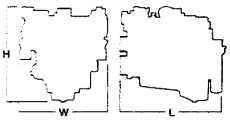
Parts that need attention are designed to be rebuilt. They include reborable blocks, over-sized pistons the same weight as originals, regrindable crankshafts, and undersized bearings.

If necessary, optional dry replacement sleeves bring bores back to standard inside dimension, even after two rebores.

You can also save time and money with exchange parts. Rebuilt to like-new standards, all carry a new warranty. Yet the cost is a fraction of new.

Or exchange your entire engine. We remanufacture thousands of 3208 engines every year, sell them for less than 60% the price of a new engine, plus provide factory warranty.

More than 200 equipment makers use 3208s in their prime products...further evidence the 3208 is a proven, dependable and reliable power plant.



3208 V8

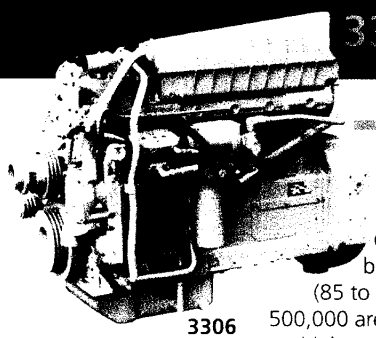
Bore x Stroke	4.5 x 5.0 in	114 x 127 mm
Displacement	636 cu in	10.4 liters
Ship Weight (NA)	1325 lb	601 kg

Approximate Dimensions (NA):		
Length	38 in	953 mm
Width	32 in	804 mm
Height	34 in	860 mm

	A Rating (Continuous)			B Rating			C Rating (Intermittent)		
	bhp	**kW**	**rpm**	**bhp**	**kW**	**rpm**	**bhp**	**kW**	**rpm**
DINA*	125	93	2400	150	112	2400	175	131	2800
	150	112	2400	175	131	2400	210	157	2800
DIT*	200	149	2400	–	–	–	225	168	2600
	200	149	2400	225	168	2400	250	187	2600
	210	156	2400	–	–	–	260	194	2600
ATAAC	–	–	–	–	–	–	300	224	2600

* Please contact Caterpillar for additional ratings.

3304/3306 Engines



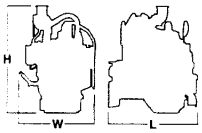
3306

The 3300 engines deliver an ideal combination of high torque rise (averages 19%) and broad operating range (85 to 325 hp). More than 500,000 are at work, many in on-highway trucks. 3304s and 3306s also power 47 models of Cat equipment.

Wide horsepower and rpm ranges assure a close match to a broad variety of applications. And the excellent torque rise of 3300 family engines produces superior lugging under heavy load. Then, when the load drops, the 3304 and 3306 accelerate quickly to rated speed.

Auxiliary drives are gear-driven. Accessories such as air compressors, water pumps and hydraulic pumps are connected mechanically, so there are no belts to break or slip, nor bearings to grease or replace.

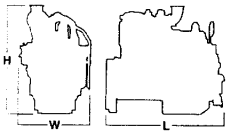
Service access is excellent. The water pump, for example, can be fully and easily serviced from the front, without disturbing the water lines or other components. To reach the impeller, only the front pump cover needs to be removed.



3304B In-Line 4

Bore x Stroke	4.75 x 6.0 in	121 x 152 mm	**Approximate Dimensions (T):**		
Displacement	425 cu in	7.0 liters	Length	38 in	969 mm
Ship Weight (T)	1670 lb	758 kg	Width	33 in	832 mm
			Height	46 in	1160 mm

	A Rating (Continuous)			B Rating			C Rating (Intermittent)			D Rating			E Rating		
	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm
PCNA	85	63	2000	–	–	–	100	75	2200	–	–	–	–	–	–
PCT	125	93	2000	–	–	–	165	123	2200	–	–	–	–	–	–
DINA	85	63	2000	90	67	2000	100	75	2200	–	–	–	110	82	2200
DIT	125	93	2000	150	112	2000	165	123	2200	175	131	2200	185	138	2200

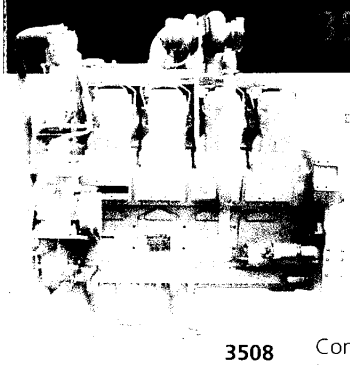


3306B In-Line 6

Bore x Stroke	4.75 x 6.0 in	121 x 152 mm	**Approximate Dimensions (T):**		
Displacement	638 cu in	10.5 liters	Length	50 in	1270 mm
Ship Weight (T)	2140 lb	970 kg	Width	31 in	790 mm
			Height	46 in	1166 mm

	A Rating (Continuous)			B Rating			C Rating (Intermittent)			D Rating			E Rating		
	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm
PCNA	125	93	2000	–	–	–	150	112	2200	–	–	–	–	–	–
PCT	190	142	2000	–	–	–	250	187	2200	–	–	–	–	–	–
PCTA	215	160	2000	–	–	–	270	201	2200	–	–	–	–	–	–
DINA	125	93	2000	135	101	2000	150	112	2200	160	119	2200	170	127	2200
DIT	155	116	2000	175	131	2000	200	149	2200	*	*	–	*	*	–
DIT	170	127	2000	200	149	2000	225	168	2200	*	*	–	*	*	–
DIT	190	142	2000	225	168	2000	250	187	2200	300	224	2200	310	231	2200
DITA	260	194	2000	275	205	2000	300	224	2200	310	231	2200	325	243	2200

3508/3512/3516 Engines



3508

The 3500 engines are the best-selling power units of their size, worldwide. One reason is design simplicity. We build them to be easy to install, easy to maintain and easy to service.

Consider service access...two inspection openings per cylinder make it easy to get at everything from the camshaft to the main bearings. Individual cylinder heads let you open up and work on a single cylinder.

To minimize parts inventory and potential assembly errors, we build 3500 engines with many common parts. For example, intake and exhaust valves, valve seat inserts and valve springs are identical.

Fuel Economy.

For many users, however, it's the 3500's fuel economy that's most attractive. These engines incorporate several proven fuel-saving design features such as four-stroke cycle design, unit fuel injectors and four valves per cylinder. Additional savings come from performance matched turbochargers and charge-air cooling.

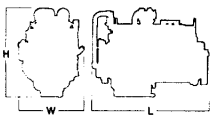
At the factory, we set individual scroll-type unit injectors for consistent, precise fuel delivery to each cylinder. Fuel is injected at 18,000 psi for superior atomization. And by producing injection pressure at the cylinder, we avoid high pressure fuel lines.

What's more, you get superior oil control and less friction from 3500 family pistons. That's because they use only three rings, unlike competitive engines that use four, five or six.

3500s are typically 5 to 15% fuel efficient than other-bran engines. In one test, compar a 3512 to an identically-rated competitive engine, the Cat engine burned 6.5% less fue In 5,000 hours of operation, t 3512 would have saved 15,0 gallons (56 800 liters) of fuel.

Reason to Repower.

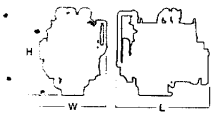
An engine that offers that kir of saving makes repowering attractive. Especially when yc add in the cost of repairing a overhauling an old, inefficien engine. Repowering with a 3 can boost production while u less fuel.



3508 V8

Bore x Stroke	6.7 x 7.5 in	170 x 190 mm	**Approximate Dimensions:**		
Displacement	2105 cu in	34.5 liters	Length, overall	76 in	1928 mm
Ship Weight	9300 lb	4218 kg	Width	57 in	1443 mm
			Height	72 in	1839 mm

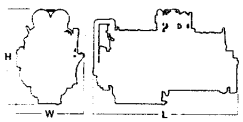
	A Rating (Continuous)			B Rating			C Rating (Intermittent)		
	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm
DITA*	680	507	1200	–	–	–	820	612	1300
	775	578	1800	–	–	–	850	634	1800
	855	638	1800	1000	746	1800	1000	746	1800



3512 V12

Bore x Stroke	6.7 x 7.5 in	170 x 190 mm	**Approximate Dimensions:**		
Displacement	3158 cu in	51.8 liters	Length, overall	97 in	2468 mm
Ship Weight	12,250 lb	5557 kg	Width	57 in	1443 mm
			Height	73 in	1853 mm

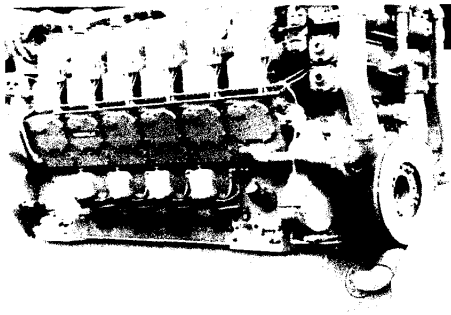
	A Rating (Continuous)			B Rating			C Rating (Intermittent)		
	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm
DITA*	1020	761	1200	–	–	–	1150	858	1300
	1175	877	1800	–	–	–	1350	1007	1800
	1280	955	1800	1500	1119	1800	1500	1119	1800



3516 V16

Bore x Stroke	6.7 x 7.5 in	170 x 190 mm	**Approximate Dimensions:**		
Displacement	4210 cu in	69 liters	Length, overall	118 in	3008 mm
Ship Weight	14,800 lb	6713 kg	Width	57 in	1443 mm
			Height	78 in	1980 mm

	A Rating (Continuous)			B Rating			C Rating (Intermittent)		
	bhp	kW	rpm	bhp	kW	rpm	bhp	kW	rpm
DITA*	1355	1011	1200	–	–	–	1665	1242	1300
	1550	1156	1800	–	–	–	1700	1268	1800



3612

The 3600s resulted from an intense 10-year development program, during which all major components underwent exhaustive bench tests. Computer-confirmed designs were tested using both finite and boundary element analysis. Then 11 prototypes were proved in lab and field tests before production began.

The end product is a family of durable, reliable engines that work hard and run long. They are designed to run 40,000 hours between major overhauls; 20,000 between minors (using No. 2 fuel).

The block is a one-piece casting, the crankshaft a press forging, induction hardened and regrindable. Bearings are steel-backed aluminum with a copper-bonded lead-tin overlay.

Cylinder liners are high alloy iron castings, water jacketed over their entire length. Pistons are two-piece, a steel crown for strength and an aluminum skirt for minimum weight. Both cylinder liners and pistons are designed for 80,000 hours use (No. 2 fuel). Valve rotators help maintain uniform temperature and wear pattern.

Fuel Efficiency.

In the past, the engineering "rule of thumb" has been that 30% of the heat generated in an engine goes to cool it, 30% exits through the exhaust, 10% is radiated from the engine...and 30% actually is power output. The design of the Cat 3600s changes that longstanding industry rule and puts 45% of the heat generated to work. Brake specific fuel consumption of the engine with two water pumps, a fuel pump and an oil pump is as low as 0.305 lb/bhp-hour (186 g/kW-hour). These pumps necessary in all applications use fuel – about .008 lb/hp-h (5 g/kW-h) – but most manufacturers do not include this fuel use in their bsfc data.

3606 In-Line 6

Bore x Stroke	11 x 11.8 in	280 x 300 mm	**Approximate Dimensions:**		
Displacement	6764 cu in	110.8 liters	Length	157 in	3988 mm
Ship Weight	33,250 lb	15 080 kg	Width	69 in	1748 mm
			Height	103 in	2626 mm

	A Rating (Continuous)		
	bhp	**kW**	**rpm**
TA	1998	1490	750
	2092	1560	800
	2320	1730	900
	2481	1850	1000

3608 In-Line 8

Bore x Stroke	11 x 11.8 in	280 x 300 mm	**Approximate Dimensions:**		
Displacement	9018 cu in	147.8 liters	Length	190 in	4828 mm
Ship Weight	40,925 lb	18 560 kg	Width	69 in	1748 mm
			Height	103 in	2626 mm

	A Rating (Continuous)		
	bhp	**kW**	**rpm**
TA	2655	1980	750
	2789	2080	800
	3084	2300	900
	3299	2460	1000

If you have economical heavy fuel available, you may want to consider heavy fuel burning 3600s.

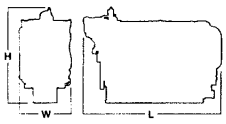
A heavy fuel configuration was part of the project when the 3600s were conceived. At the same time design work began, we launched a major program to study the characteristics of heavy fuel. By the time the engines went into production, we knew how heavy fuel affected an engine's performance and durability.

We tested 3600 engine performance on fuels with viscosities up to 700 cSt (at 50 degrees C), the consistency of tar. To simulate the poorest commercially-available fuel, we added 5% sulfur and 600 ppm of vanadium. After 10 years and 80,000 hours of testing distillate and heavy fuels, the Cat heavy fuel-burning 3600s were ready for release.

Special components enable them to run efficiently and economically on the heaviest fuel available. To equip a 3600 engine for the greater pressures and higher temperatures associated with burning heavy fuel, we install:

- Fuel injectors optimized for high viscosity fuel.
- Cooling for fuel injector nozzle tips.
- Flange-cooled cylinder liners.
- Recessed nimonic 80A exhaust valves.
- Watercooled valve inserts.
- High mass flow turbochargers.
- Turbocharger water wash.
- Remote-mounted, heated fuel filter.

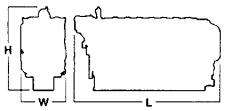
By substituting parts, typically at overhaul time, you can convert 3600 engines from distillate to heavy fuel configurations, and vice versa.



3512 V12

Bore x Stroke	11 x 11.8 in	280 x 300 mm	**Approximate Dimensions:**		
Displacement	13,527 cu in	221.7 liters	Length	180 in	4562 mm
Ship Weight	53,030 lb	24 050 kg	Width	67 in	1704 mm
			Height	127 in	3231 mm

	A Rating (Continuous)		
	bhp	**kW**	**rpm**
TA	3996	2980	750
	4184	3120	800
	4640	3460	900
	4962	3700	1000



3516 V16

Bore x Stroke	11 x 11.8 in	280 x 300 mm	**Approximate Dimensions:**		
Displacement	18,036 cu in	295.6 liters	Length	216 in	5482 mm
Ship Weight	64,430 lb	29 220 kg	Width	67 in	1704 mm
			Height	127 in	3231 mm

	A Rating (Continuous)		
	bhp	**kW**	**rpm**
TA	5310	3960	750
	5579	4160	800
	6169	4600	900
	6598	4920	1000

Factory and dealer professionals will help you select the right engine, get it installed, even help you finance it. And they'll be there to support you, anywhere in the world. More than 1300 dealer sales, parts and service facilities in more than 150 countries are backed by Caterpillar's network of computer-linked parts distribution facilities.

We can train your mechanics. Maintenance and repair programs, tailored to your needs, can be provided on site, at a Cat dealer location or at one of Caterpillar's training centers.

To Find Out More. . .

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If you don't know your Cat Dealer, contact your nearest Caterpillar office.

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