

RENEWABLE ENERGY TECHNOLOGIES

ORC AND STEAM EXPANDERS

POWER RECOVERY AND
POWER GENERATION THROUGH
HEAT AND PRESSURE

- Capacities from 50kW to Multi-Megawatts
- Oil free screw expanders for steam or gases expansion
- Lubricated screw expander for Kaishan ORC
- Pressure regulation in steam or gas pipelines
- Flash steam and brine from geothermal wells can be accepted
- Wasted heat recovery systems for any kind of hot fluid
- Wasted pressure recovery systems in steam pipelines
- Low cost investment, easy to install and maintain





Kaishan's No. 1 Industrial Park at Quzhou occupies a land area of 2.8 million square feet.



Kaishan's Shuangqiao Industrial Park in Chongqing occupies an area of 860,000 square feet.



Guangdong Ganey Precision Machinery Co., Ltd. occupies an area of 540,000 square feet.



Kaishan's Lingang Industrial Park in Shanghai occupies an area of 1.3 million square feet.

ABOUT US

Over the last sixty years, the Kaishan Group has steadily grown to become a significant, diversified engineering company developing high value machinery for industry worldwide.

With modern specialized manufacturing facilities positioned in seven strategic locations, Kaishan is the world's third largest manufacturer of compressed air mining and drilling equipment. Today we produce over 60,000 rotary screw and 250,000 reciprocating compressors annually. Supporting these production facilities, Kaishan Group, including thirty-two subsidiary companies, supplies compressed air and mining equipment to over sixty countries and regions including the USA, Australia, Germany, Japan, Korea, Russia, Africa and throughout Latin America.

Research and development for all new compressor products is done in Seattle, WA, USA. Combining highly skilled engineering with low cost manufacturing allows us to provide performance-proven, reliable equipment of optimum value to our customers. Kaishan's manufacturing processes are 85% vertically integrated insuring full control of the material supply chain, component cost and quality.

This unique control of the material supply chain affords Kaishan the ability to respond rapidly to changing market demands. Integral in the design and manufacture of our products is outstanding energy efficiency and field-proven reliability. Kaishan's fundamental belief in environmental sustainability drives our focus on producing products that maximize energy efficiency, meeting the needs of industry now and into the future and helping to preserve our

precious energy resources. Single- and two-stage compressors that produce more compressed air per unit of power input as well as expanders that utilize waste heat to produce electricity are just two of the fundamental products in our sustainable approach.

Throughout our manufacturing processes, unused waste materials are rigorously recycled at every stage to maximize the use of our raw materials. The positive impact for our customers is that of outstanding engineering with a pioneering spirit and a focus on continuous improvement. Kaishan will continue to develop more technologies and unique manufacturing techniques providing industry with machinery of exceptional value—now and well into the future.



Screw rotor workshop

Air center

MHU machine center imported from Japan

German Hermle five-axis grinding machine center

High-precision three-coordinate measuring apparatus

KAISHAN INNOVATION:

Kaishan has developed and patented the innovative screw expander that can be used to replace the conventional turbines improving the isentropic efficiency up to almost 90%. Through this innovation Kaishan is the leader in waste heat recovery systems and waste pressure recovery systems at low temperatures and pressure. Using our technology Kaishan is recovering near to 100MW around

the world with short payback and reducing CO2 emissions and heat to the atmosphere. The use of Kaishan screw expander systems can be grouped with other renewable energies such as co-generation, waste heat recovery and waste pressure recovery. The Kaishan screw expanders and ORCs are versatile, easy to install and provide low maintenance costs.



Steam Expander

The Kaishan power plant using direct expansion through our Kaishan oil free screw expander generates power expanding steam or gases. It can also be used as a valve to drop the pressure in steam pipelines or added to a boiler as a thermal plant burning any fuel as coal, gas, diesel, biomass, etc. This technology has the same characteristics of steam turbines.



Organic Rankine Cycle (ORC)

The ORC power plant using Kaishan oil injected screw expander can be used to convert heat from fluid such as exhaust gases, hot jacket water, geothermal hot water, hot air or thermal oils into electricity. The ORC can also be used as a condensation system.

DIRECT STEAM OR GAS EXPANSION POWER PLANT USING KAISHAN OIL FREE SCREW EXPANDER

This is the most innovative product to generate clean energy through expanding steam or gases. Our expander can accept saturated, dry or overheated steam as well any kind of gas with the exception of O₂ and H₂. During the

condensation, the steam or gas can be discharged at any desired pressure—even at vacuum. While the expansion process is made, the system will generate power that will be transferred and regulated by the electrical control.

DIRECT EXPANSION APPLICATIONS

- Drop and control the pressure in steam and gas pipelines.
- Steam thermal plants burning any kind of fuel.
- Flash steam expansion from geothermal wells.
- Expansion and/or condensation of wasted steam to recirculate hot water to a boiler.
- Take advantage of any differential pressure in steam pipelines.

POWER GENERATION FROM DIRECT STEAM EXPANSION

Using this table, it is easy to estimate the net power generated in kW per ton/h of saturated steam:

In the first row, find the steam inlet pressure, in the first column find the desired outlet pressure, look for the

intersection at the table and get the net power generated in kW for every ton of steam per hour, multiply the value of the intersection per ton/h mass flow and get the estimate of net power to generate. The values are for reference only.

		Inlet pressure (barg)																														
Outlet pressure (barg)	barg	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1.5	
	psig	441	426	412	397	382	368	353	338	323	309	294	279	265	250	235	221	206	191	176	162	147	132	118	103	88	74	59	44	29	22	
	29	426	1.2																													
	28	412	2.4	1.2																												
	27	397	3.7	2.5	1.3																											
	26	382	5.0	3.8	2.6	1.3																										
	25	368	6.4	5.2	4.0	2.7	1.4																									
	24	353	7.8	6.6	5.4	4.1	2.8	1.4																								
	23	338	9.2	8.1	6.9	5.6	4.3	2.9	1.5																							
	22	323	10.8	9.6	8.4	7.1	5.8	4.5	3.0	1.6																						
	21	309	12.3	11.2	10.0	8.7	7.4	6.1	4.6	3.2	1.6																					
	20	294	14.0	12.8	11.6	10.4	9.1	7.7	6.3	4.8	3.3	1.7																				
	19	279	15.7	14.5	13.3	12.1	10.8	9.5	8.0	6.6	5.1	3.5	1.8																			
	18	265	17.4	16.3	15.1	13.9	12.6	11.3	9.9	8.4	6.9	5.3	3.8	1.9																		
	17	250	19.3	18.2	17.0	15.8	14.5	13.2	11.8	10.3	8.8	7.2	5.6	3.8	2.0																	
	16	235	21.3	20.2	19.0	17.8	16.5	15.2	13.8	12.3	10.8	9.3	7.6	5.9	4.0	2.1																
	15	221	23.4	22.2	21.1	19.9	18.6	17.3	15.9	14.5	13.0	11.4	9.8	8.0	6.2	4.2	2.2															
	14	206	25.5	24.4	23.3	22.1	20.8	19.5	18.1	16.7	15.2	13.7	12.1	10.3	8.5	6.5	4.5	2.3														
	13	191	27.9	26.8	25.6	24.4	23.2	21.9	20.5	19.1	17.6	16.1	14.4	12.7	10.9	9.0	6.9	4.8	2.5													
	12	176	30.3	29.2	28.1	26.9	25.7	24.4	23.0	21.6	20.2	18.6	17.0	15.3	13.5	11.6	9.6	7.4	5.1	2.7												
	11	162	33.0	31.9	30.8	29.6	28.4	27.1	25.7	24.4	22.9	21.4	19.8	18.1	16.3	14.4	12.4	10.2	8.0	5.5	2.9											
	10	147	35.8	34.8	33.6	32.5	31.3	30.0	28.7	27.3	25.8	24.3	22.7	21.0	19.3	17.4	15.4	13.3	11.0	8.6	5.9	3.1	1.7									
	9	132	38.9	38.0	36.8	35.6	34.4	33.1	31.8	30.4	29.0	27.5	25.9	24.2	22.5	20.6	18.7	16.6	14.3	11.9	9.3	6.5	3.4									
	8	118	42.3	41.3	40.2	39.0	37.8	36.6	35.3	33.9	32.5	31.0	29.4	27.8	26.0	24.2	22.2	20.1	17.9	15.5	12.9	10.1	7.1	3.7								
	7	103	46.0	45.0	43.9	42.8	41.6	40.4	39.1	37.7	36.3	34.8	33.3	31.7	29.9	28.1	26.2	24.1	21.9	19.5	16.9	14.2	11.1	7.8	4.1							
	6	88	50.2	49.2	48.1	47.0	45.8	44.6	43.3	42.0	40.6	39.1	37.6	36.0	34.3	32.5	30.5	28.5	26.3	24.0	21.4	18.7	15.7	12.4	8.7	4.7						
	5	74	54.9	53.9	52.9	51.8	50.6	49.4	48.1	46.8	45.5	44.0	42.5	40.9	39.2	37.4	35.5	33.5	31.4	29.0	26.5	23.8	20.8	17.6	14.0	9.9	5.3	6.2				
	4	59	60.4	59.4	58.4	57.3	56.2	55.0	53.7	52.4	51.1	49.7	48.2	46.6	45.0	43.2	41.3	39.3	37.2	34.9	32.4	29.8	26.8	23.6	20.0	16.1	11.5	7.5	3.1			
	3	44	67.0	66.0	65.0	63.9	62.7	61.4	59.2	57.8	56.4	55.0	53.4	51.8	50.1	48.2	46.3	44.2	41.9	39.5	36.8	34.0	30.8	27.3	23.4	18.9	13.7	7.5				
	2	29	75.3	74.3	73.3	72.2	71.0	69.6	67.6	66.3	64.9	63.5	62.0	60.4	58.7	56.9	54.9	52.9	50.7	48.3	45.7	42.9	39.8	36.3	32.5	28.1	23.0	17.0	9.6			
	1	15	86.4	85.4	84.4	83.2	82.4	81.3	80.0	79.0	77.7	76.4	75.0	73.5	72.0	70.3	68.5	66.7	64.7	62.5	60.2	57.7	55.0	51.9	48.6	44.8	40.5	35.6	29.7	22.5	13.1	
	0	0	104.3	103.5	102.5	101.6	100.6	99.5	98.4	97.3	96.1	94.8	93.5	92.1	90.6	89.0	87.3	85.6	83.6	81.6	79.4	77.0	74.3	71.4	68.2	64.6	60.5	55.7	50.1	43.1	34.2	12.6
-0.1	-1.5	106.9	106.0	105.1	104.2	103.2	102.2	101.1	99.9	98.7	97.5	96.2	94.8	93.3	91.7	90.1	88.3	86.4	84.4	82.1	79.8	77.1	74.3	71.1	67.5	63.4	58.6	53.0	46.1	37.2	31.6	
-0.2	-2.9	109.8	108.8	108.0	107.1	106.1	105.1	104.0	102.9	101.7	100.5	99.2	97.8	96.3	94.7	93.1	91.3	89.4	87.4	85.2	82.9	80.2	77.4	74.2	70.6	66.6	61.9	56.3	49.4	40.6	35.0	
-0.3	-4.4	113.0	112.2	111.3	110.3	109.4	108.4	107.3	106.2	105.0	103.8	102.5	101.1	99.6	98.1	96.4	94.7	92.8	90.8	88.7	86.3	83.7	80.9	77.7	74.2	70.2	65.5	59.9	53.1	44.3	38.8	
-0.4	-5.9	116.7	115.9	115.0	114.0	113.1	112.1	111.0	109.9	108.7	107.5	106.3	105.0	103.5	101.9	100.3	98.6	96.7	94.7	92.6	90.2	87.7	84.9	81.7	78.2	74.2	69.6	64.1	57.3	48.3	43.1	
-0.5	-7.4	121.0	120.1	119.3	118.3	117.4	116.4	115.3	114.2	113.1	111.9	110.6	109.3	107.9	106.3	104.7	103.0	101.2	99.2	97.1	94.8	92.2	89.5	86.4	82.9	78.9	74.3	68.9	62.2	53.6	48.1	
-0.6	-8.9	125.3	124.3	123.5	122.5	121.6	120.5	119.4	118.2	117.1	115.9	114.6	113.2	111.7	110.1	108.4	106.6	104.6	102.5	100.3	97.7	95.0	91.9	88.5	84.6	80.0	74.6	68.0	59.5	54.1		
-0.7	-10.3	130.3	129.1	128.0	126.9	125.8	124.7	123.5	122.3	121.2	119.8	118.3	116.8	115.1	113.3	111.4	109.3	107.1	104.6	101.9	98.9	95.5	91.7	87.2	81.9	75.3	68.9	61.6				
-0.8	-11.8	141.2	140.4	139.6	138.7	137.9	136.9	135.9	134.9	133.8	132.7	131.5	130.2	128.8	127.4	125.9	124.3	122.5	120.6	118.6	116.4	114.0	111.3	108.4	105.0	101.3	96.9	91.7	85.3	77.0	71.8	
-0.90	-13.2	155.4	154.6	153.8	153.0	152.2	151.3	150.3	149.3	148.3	147.2	146.0	144.8	143.5	142.1	140.6	139.1	137.4	135.6	133.6	131.5	129.1	126.3	123.7	120.5	116.8	112.6	107.5	101.3	93.3	88.2	

Steam pressure regulation: Pressure regulation from 24barg to 10barg. Steam flow rate 4.5ton/h.

$$Power\ output_{Net} = 28.7\ kW / \frac{T_{on}}{h} \times 4.5\ T_{on}/h = 129\ kW$$

Steam expansion until condensation: steam at 6 barg inlet pressure to be expanded up to – 0.85 barg.
Steam flow rate 10 ton/h.

$$Power\ output_{Net} = 116,8\ kW / \frac{T_{on}}{h} \times 10\ T_{on}/h = 1168\ kW$$

POWER GENERATION FROM PROCESS OR WASTED HEAT

The ORC is used for the transformation of heat into clean electricity. Your power supply is the heat from hot fluids like liquid or gaseous fluids that can be driven to an evaporator. There the refrigerant will evaporate and will raise your pressure. Once this gas expands into the lubricated screw expander it will generate movement and at the same time electricity. Then the refrigerant is condensed and through a fluid pump, it will return to the evaporator to continue absorbing heat and continuously generate electricity .



ORC APPLICATIONS

Power generation applications from hot fluids, liquids or gases:

- Water used for engine cooling circuits, or any machine or process that raises to 80°C and above.
- Geothermal hot water (brine).
- Processes hot fluids: ethanol, gasoline, water, low pressure to condensate steam, thermal oil, chemicals, etc.
- Hot exhaust gases from combustion in gas turbines or internal combustion engines burning gas or diesel.
- Hot gases from kilns and furnaces in industries like cement, glass, steel, etc.
- Solar thermal energy generated by hot water or steam.
- Any application where heat can be transferred to a fluid and taken to the ORC.

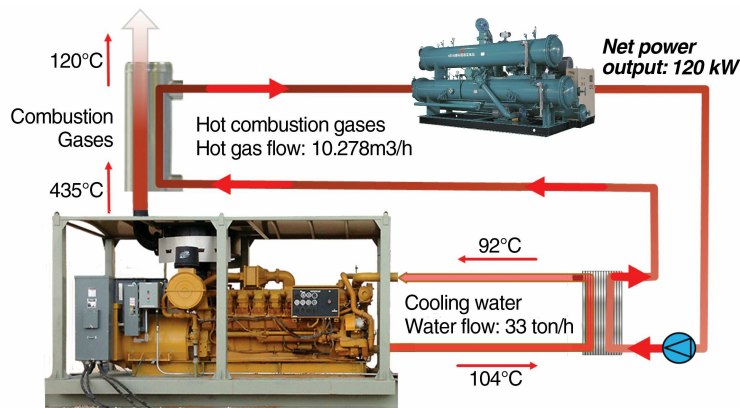
ORC AND EXPANDERS TECHNICAL SPECIFICATIONS

- Generation capacity from 50kW to Multi-Megawatts.
- Kaishan oil free/lubricated screw expanders with high isentropic efficiency.
- Efficient performance for unsteady flow conditions without losing efficiency.
- Intake of any kind of steam—dry, saturated, superheated or flash for direct expansion.
- Admission of all kinds of gases except H_2 and O_2 for direct expansion.
- Three different options for condensers: evaporative, air cooled or water cooled heat exchanger.
- Expanders with SKF bearings for 100,000 hours of duty and John Crane seals.
- Heat exchangers are built to ASME standards.
- Induction or synchronous generator for any voltage and frequency.
- Control with Siemens PLC for controlling and remote monitoring.
- High efficiency and reliability.
- Environmentally friendly refrigerant.
- Zero emissions, without byproducts.
- Easy and inexpensive installation.

SUCCESS CASE: WASTE HEAT RECOVERY IN INTERNAL COMBUSTION ENGINE

In a power generating plant, the hot gases of combustion and heat from the engine cooling water circulate to produce clean electricity. The heat is taken to the ORC through a water circuit which first exchanges heat with the cooling

water and then with hot combustion gases. Finally this hot water reaches the evaporator of the ORC where it evaporates the refrigerant gas which then expands in the Kaishan Screw Expander.



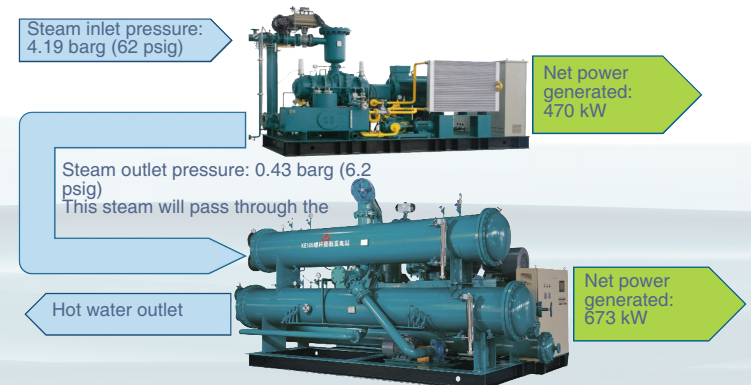
- Features Caterpillar G3516
- Engine capacity: 1000kW
- Cooling type: water
- Fuel: Biogas

Characteristics of the installed ORC

- Additional net power generated: 120kW
- Engine increased efficiency: 12%
- Reduction in CO_2 emissions: 865 ton/year
- Savings equivalent in tons of coal per year: 365 ton/year

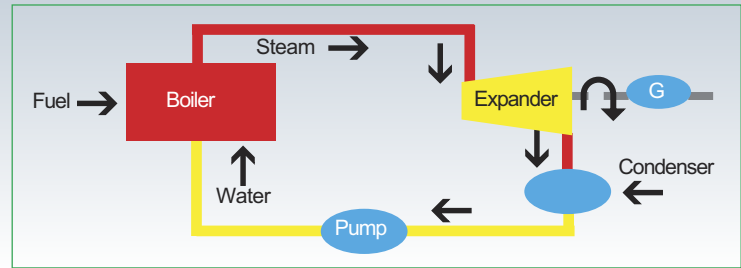
SUCCESS CASE: TWO STAGE HYBRID SYSTEM

In a steel mill, 9.5ton/hour of steam was used and steam pressure was reduced in the first stage from 4.19 barg (62 psig) down to 0.43 barg (6.2 psig) while generating a net of 470 kW; then an ORC was used for the condensation of the steam (at 110°C) to obtain hot water at 50°C and generate an additional 673 kW. The total amount of clean energy generated is a net 1143 kW. Currently the steel mill has three equal systems that allows them to retrieve nearly 3.5 MW and has the additional benefit of reducing CO_2 emissions to 23.072 ton/year and recover up to 219,400 ton/year of water.



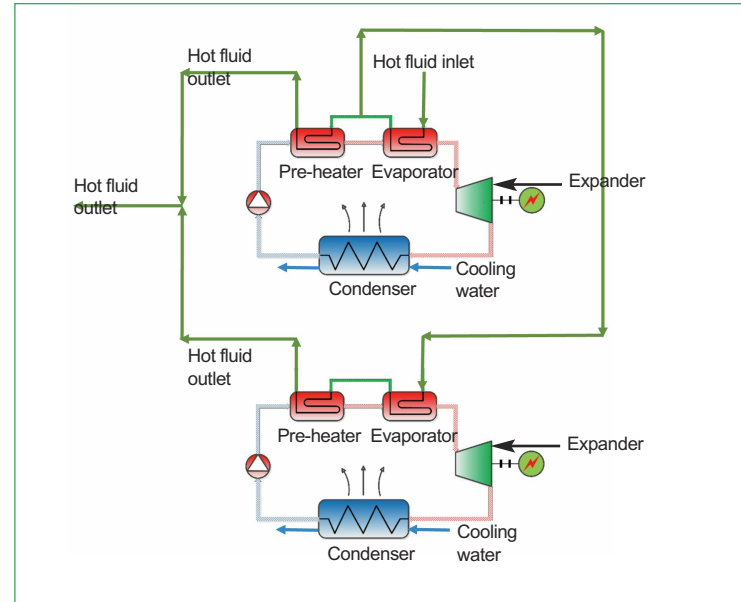
STEAM THERMAL PLANTS

Energy generation using steam from a boiler burning fuels like: coal, gas, diesel, biomass, etc. Boilers or heat exchangers that use the heat from recovery systems in hot exhaust gases or any source that generate steam in the required conditions.



SUCCESS CASE: WATER COOLING IN REFINERY

- Fluid: Water
- Flow capacity: 200t/h
- Water inlet temperature: 118°C
- Water outlet temperature: 70°C
- Net power output at the annual average ambient temperature 25°C: 907 kW
- Net power output at the hottest monthly average ambient temperature 34°C: 789 kW



SUCCESS CASE: GASOLINE COOLING IN SINOPEC REFINERY

- Fluid: Gasoline
- Fuel flow capacity: 125 t/h
- Gasoline Inlet temperature: 135°C
- Gasoline outlet temperature: 70°C
- Special specification: Explosion proof system
- Net power output: 546kW



SUCCESS CASE: TEAM DIRECT EXPANSION

- Decompressing low pressure steam generated in cooling process in a steel factory
- Inlet steam pressure: 4.19barg (62psig)
- Outlet steam pressure: 0.43barg (6.2psig)
- Steam flow rate: 9.5Ton/hour

Inlet pressure:
4.19barg

Outlet pressure:
0.43barg



Power generated:
470kW

SUCCESS CASE: GEOTHERMAL POWER PLANT, UNITED STATES

In the case of geothermal energy from hot water (brine) in Lightning Dock, New Mexico, 4 plants of 1 MW were installed.

2400 gallons per minute of water at 149°C pass through the system, then fresh water is reinjected into the soil.



SUCCESS CASES IN ASIA AND UNITED STATES

KAISHAN has installed ORC, Steam Expanders (SE)) and HYBRIDS (SE+ORC) in Asia and the United States, in steel mills, refineries, chemical plants, oil palm processing plants, low enthalpy geothermal energy sites, and facilities burning solid waste, among others. The total of the net power

currently generated is more 100MW including recent projects—power previously wasted into the atmosphere. Kaishan is a leader worldwide in waste heat recovery and waste pressure recovery systems utilizing its screw expanders technology.

CUSTOMER	PLANT	PLANT TOTAL POWER (KW)
JIANSU CHENXING PHOSPHATING PLANT	SE	4351
TANSHANG GUOYI SPECIAL STEEL	SE	3110
XUZHOU HUAHONGTE STEEL	SE	2450
JINGHUA CHEMICAL	SE	319
SHENFANG ZHISHANG CHEMICAL	SE	122
HEBEI XUN STEEL GROUP	SE + ORC	4638
PHILIPPINES PALM OIL PLANTATION	SE + ORC	3164
DONGYA STEEL	SE + ORC	2730
TIANFENG STEEL	SE + ORC	2582
QUZHOU YASHENG	SE + ORC	2456
HENANG YAXIN STEEL	SE + ORC	2386
SHANDONG RUXING STEEL PIPING	SE + ORC	1620
JIANGSHU YANGGANGTE STEEL	SE + ORC	1460
HUBEI WUGANG WULONG MINING	SE + ORC	1454
PHILIPPINES PALM TREE PROCESSING PLANT	SE + ORC	1183
HEBEI KAIYUE CHEMICAL	SE + ORC	996
SHANDONG LAIGANG YUNFENG STEEL	SE + ORC	958
NIBONG SOLID WASTE	SE + ORC	688
TIANJING TIANGANG LIANGHE STEEL	SE + ORC	572

CUSTOMER	PLANT	PLANT TOTAL POWER (KW)
SHANDONG XINHUA	SE + ORC	417
HARBING BOYING PHOSPATING CHEMICAL	SE + ORC	275
HEBEI CHONGLI STEEL	SE + ORC	250
DONGYA STEEL - SECOND PHASE QIUTUAN	SE + ORC	222
XUZHOU HUAHONGTE STEEL	ORC	3358
CYRQ ENERGY USA- GEOTHERMAL POWER PLANT	ORC	2800
ZHEJIANG SHUYANG CHEMICAL	ORC	2100
SHANDONG YUNXING	ORC	1340
SCECHUAN HENGDA MINING	ORC	1278
CHINA SINOPEC OIL REFINEARY PLANT, HAINAN	ORC	1113
XICHEN STEEL	ORC	700
SHANDONG HENLI	ORC	694
ANHUI WUYUAN CHEMICAL	ORC	350
CHENA HOT SPRING, ALASKA USA	ORC	300
HEBEI TIANZHU STEEL	ORC	218
XIAMEN HONGSHEN MECHANICAL EQUIPMENT	ORC	207
GENERAL ELECTRIC INDIA	ORC	172
ZHONGCHAI ENERGY SAVING COMPANY	ORC	138
QINGHAI GEOTHERMAL	ORC	114
DELI XICHANGJIANG ENVIROMENTAL COMPANY	ORC	109

KAISHAN COMPRESSOR—THE WORLD'S THIRD LARGEST COMPRESSOR MANUFACTURER



MODEL	COMPRESSOR TYPE	FEATURES
KRSP2	Two Stage	Global leader in air compressor efficiency
KRSP	Single Stage	Patented "SKY" air end, triple SKF bearings
KRSD	Single Stage	Direct drive, TEFC motor, low sound enclosure
KRSB	Single Stage	Belt drive, economical to own and operate
KRSH	Two Stage High Pressure	Pressure to 580 PSI
KRSL	Single Stage Low Pressure	Pressure as low as 15 PSI
KRSV	Rotary Screw Vacuum Pump	World class vacuum efficiency

OTHER KAISHAN PRODUCTS



Filtration



Air Treatment



Portable Compressors



Gas Compressors



Pressure Vessels



Steam Expanders



ORC Expanders

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