

Charting a Course to Energy Independence

Providence, RI
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Magnetic Bearing Chiller Compressor

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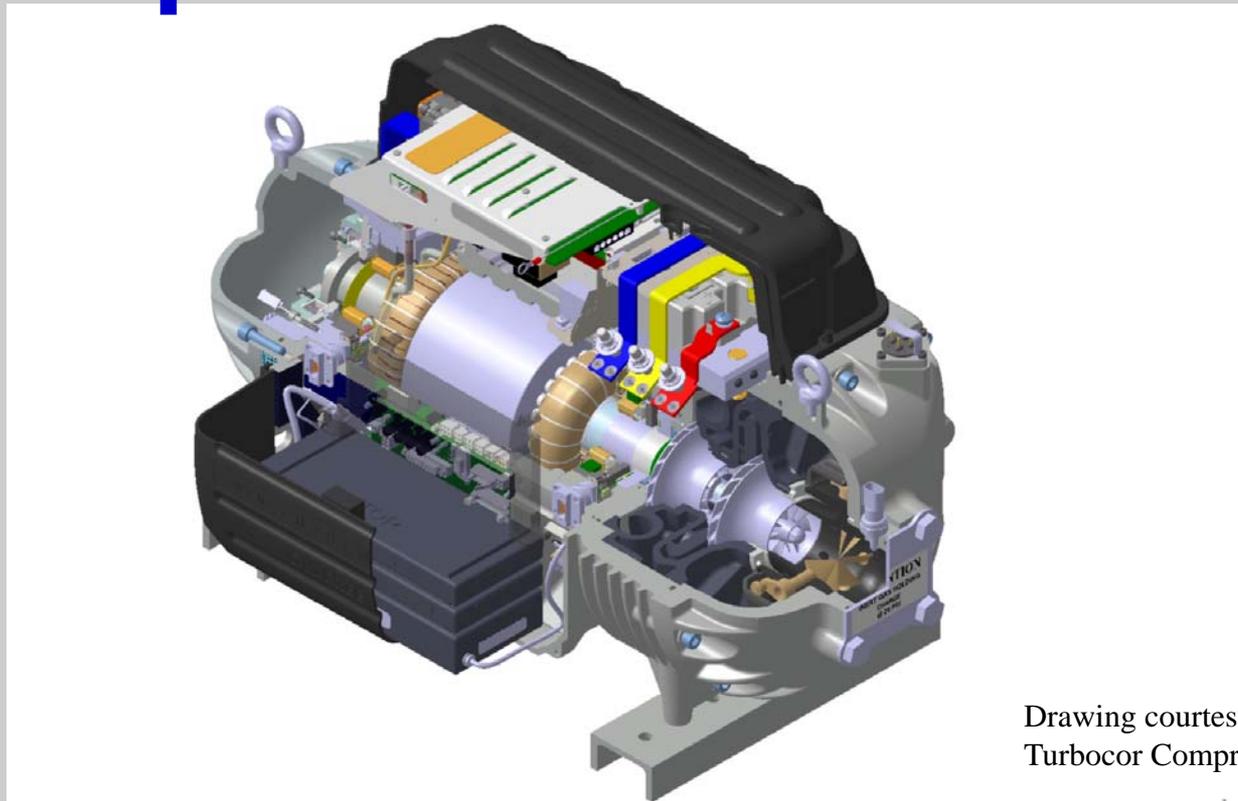
Magnetic Bearing Chiller Compressor

- **What is it, how does it work?**
- **Data from projects**
- **Where does it work best?**



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The Magnetic Bearing Chiller Compressor at a Glance



Drawing courtesy of Danfoss
TurboCor Compressors, Inc.





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3 ea. 80 ton chiller compressors with magnetic bearings

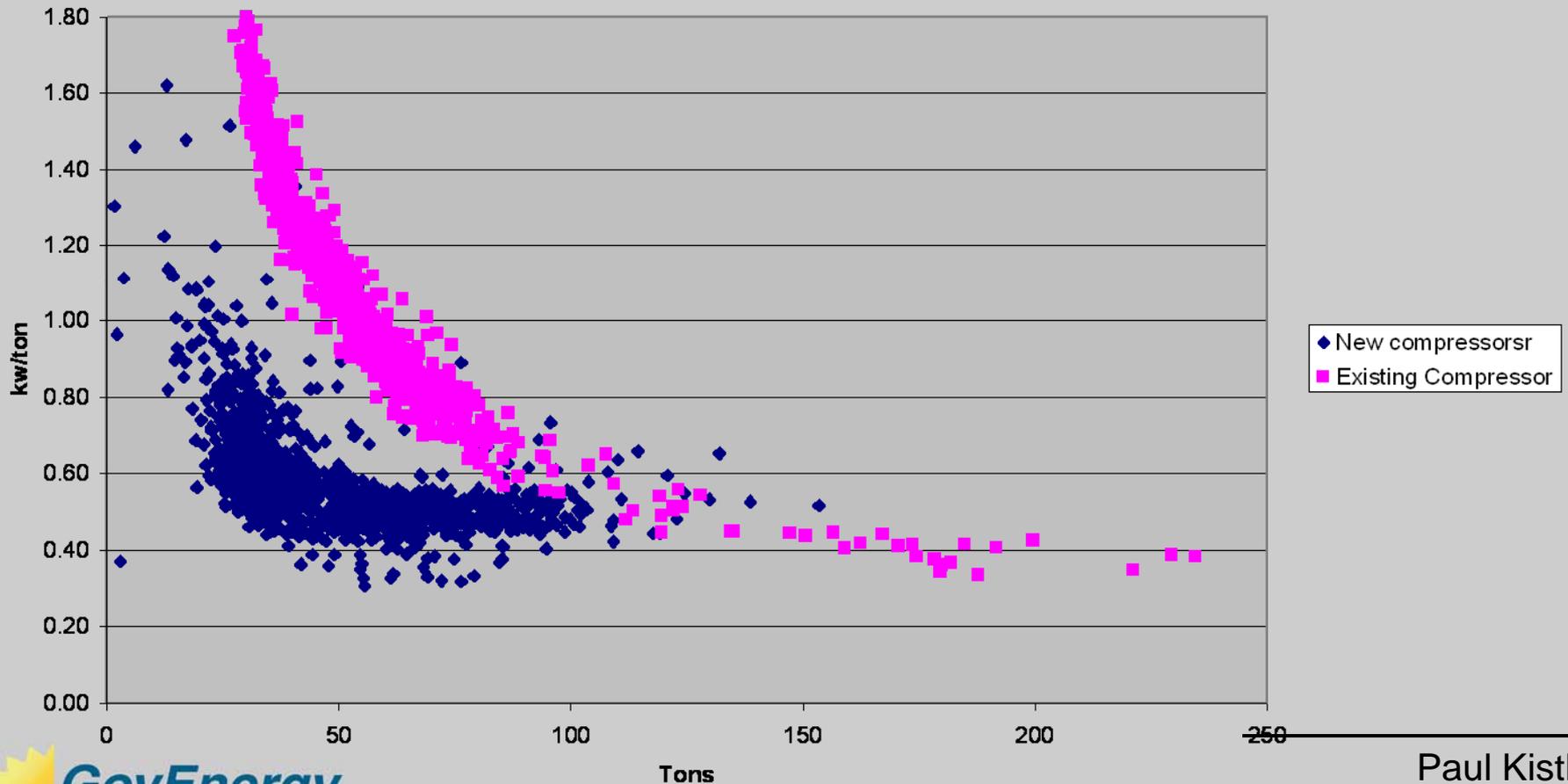
NRSW San Diego CA





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Kw/ton vs. Load
New vs. Existing Compressor
San Diego, CA
Jan 06





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**TABLE NUMBER 3
SAN DIEGO JANUARY 06**

Existing Chiller

| | Chilled Water Flow Rate (gpm) | Chilled Water Temp. in (°F) | Chilled Water Temp. out (°F) | Chilled Water Temp. Delta | Load (tons) | Condensing Water Temp. (°F) | Electrical Demand (KW) | Efficiency (KW/ton) |
|----------------|--------------------------------------|------------------------------------|-------------------------------------|----------------------------------|--------------------|------------------------------------|-------------------------------|----------------------------|
| Minimum | 427 | 46 | 44 | 0.0 | 0 | 68 | 0 | 0.32 |
| Maximum | 512 | 59 | 54 | 14.7 | 290 | 75 | 94 | 2.53 |
| Average | 485 | 47 | 45 | 2.4 | 48 | 71 | 47 | 1.11 |

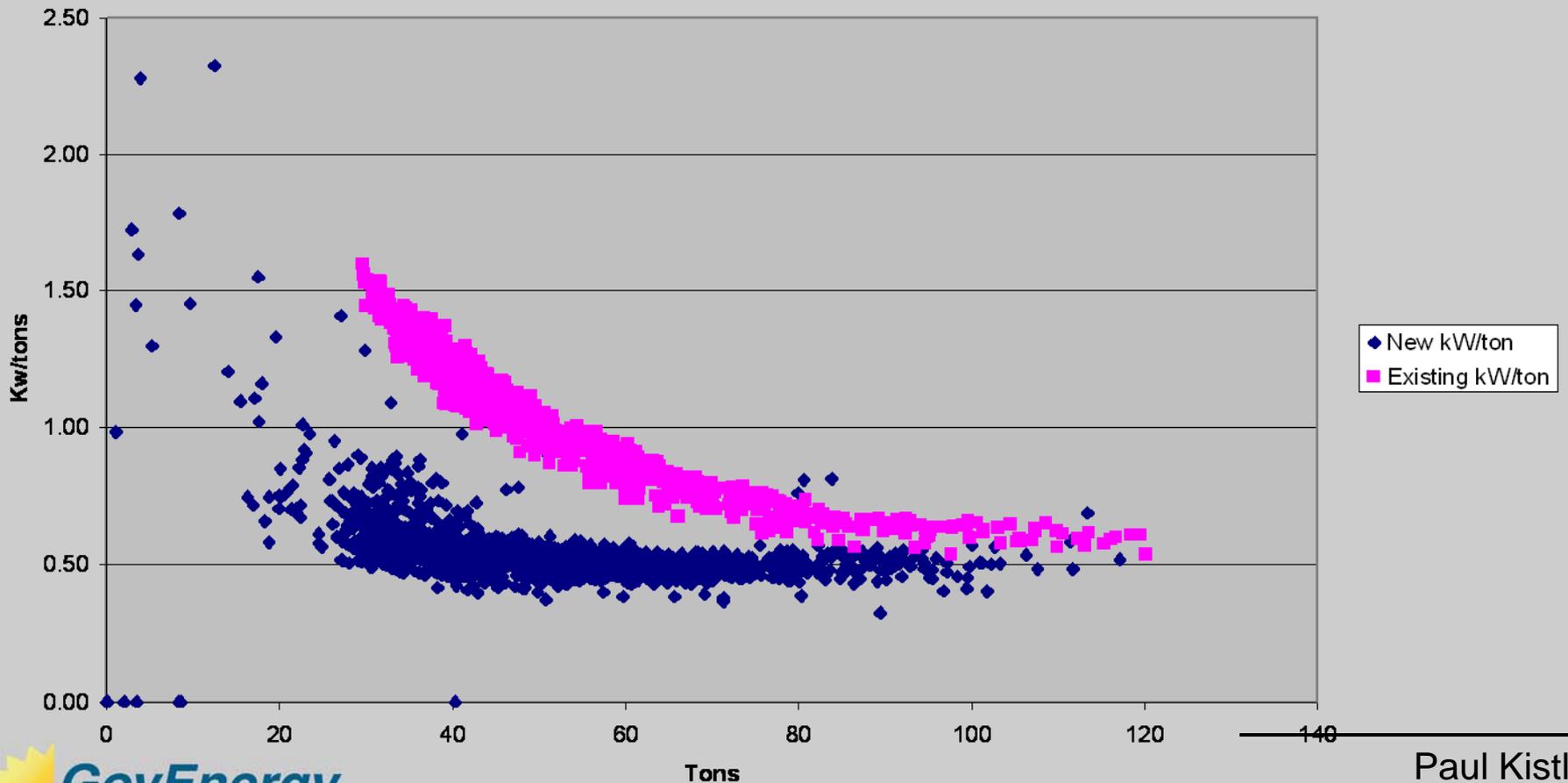
New Compressors

| | | | | | | | | |
|----------------|-----|----|----|-----|-----|----|-----------|-------------|
| Minimum | 421 | 45 | 41 | 0.5 | 0 | 65 | 0 | 0.31 |
| Maximum | 484 | 52 | 48 | 7.8 | 153 | 76 | 86 | 2.69 |
| Average | 462 | 47 | 45 | 2.5 | 44 | 69 | 25 | 0.59 |



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New vs. Existing Compressor
Kw/ton vs. Load
San Diego, CA
April 06





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**TABLE NUMBER 4
SAN DIEGO APRIL 06**

Existing Chiller

| | Chilled Water Flow Rate (gpm) | Chilled Water Temp. in (°F) | Chilled Water Temp. out (°F) | Chilled Water Temp. Delta | Load (tons) | Condensing Water Temp. (°F) | Electrical Demand (KW) | Efficiency (KW/ton) |
|----------------|--------------------------------------|------------------------------------|-------------------------------------|----------------------------------|--------------------|------------------------------------|-------------------------------|----------------------------|
| Minimum | 440 | 44 | 44 | 0.0 | 0 | 68 | 0 | 0.54 |
| Maximum | 509 | 53 | 53 | 5.8 | 120 | 75 | 73 | 1.67 |
| Average | 485 | 44 | 44 | 2.6 | 52 | 72 | 51 | 1.04 |

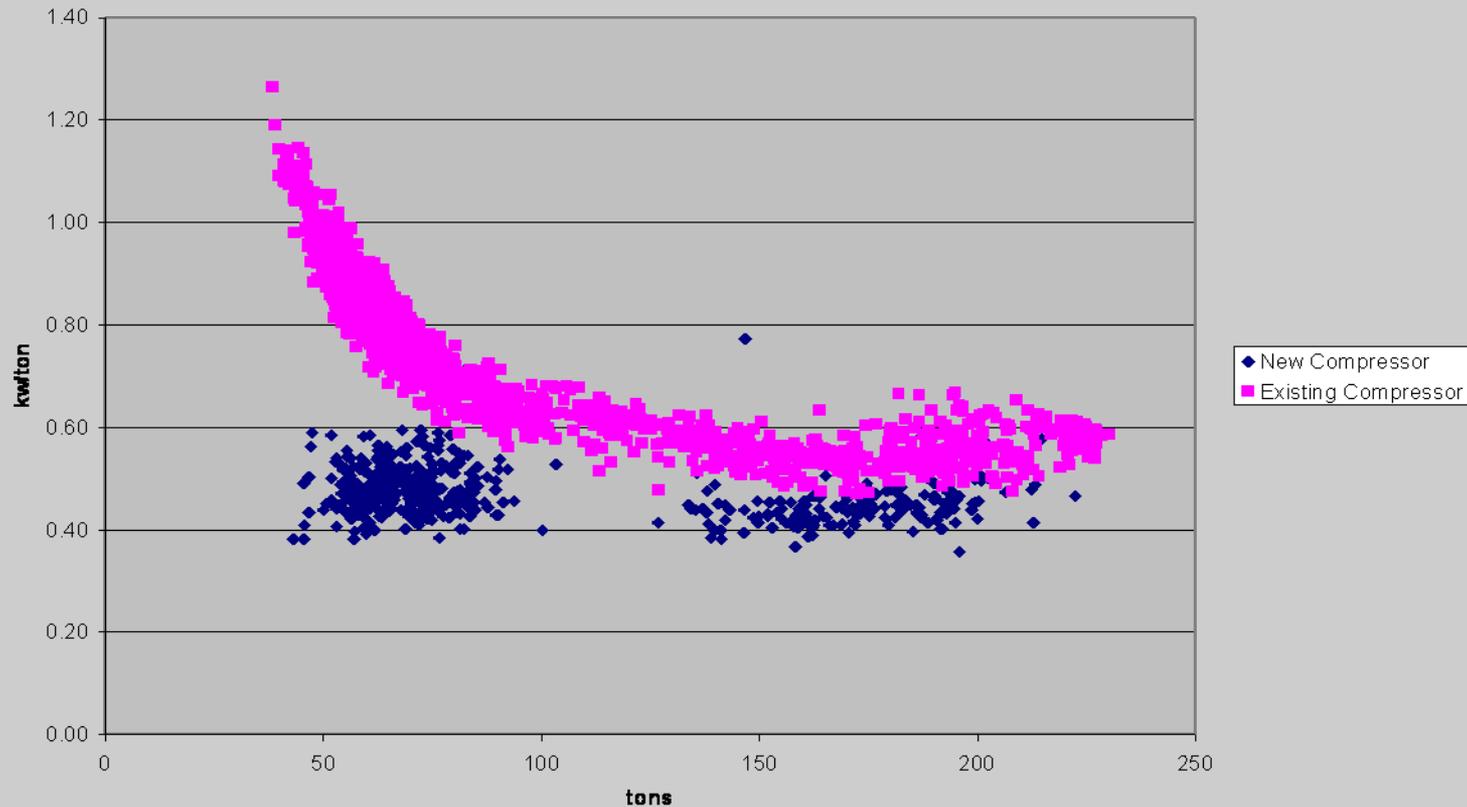
New Compressors

| | | | | | | | | |
|----------------|-----|----|----|-----|-----|----|-----------|-------------|
| Minimum | 429 | 45 | 41 | 0.0 | 0 | 65 | 0 | 0.00 |
| Maximum | 492 | 51 | 49 | 6.1 | 117 | 75 | 78 | 2.32 |
| Average | 460 | 47 | 45 | 2.6 | 49 | 69 | 26 | 0.55 |



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New vs. Existing Compressor kW/ton vs. load San Diego July/Aug 06





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SAN DIEGO DATA AUGUST 2006

Existing Chiller

| | Chilled Water Flow Rate (gpm) | Chilled Water Temp. in (°F) | Chilled Water Temp. out (°F) | Chilled Water Temp. Delta | Load (tons) | Condensing Water Temp. (°F) | Electrical Demand (KW) | Efficiency (KW/ton) |
|----------------|-------------------------------|-----------------------------|------------------------------|---------------------------|-------------|-----------------------------|------------------------|---------------------|
| Minimum | 435 | 46 | 44 | 1.9 | 39 | 69 | 42 | 0.47 |
| Maximum | 520 | 57 | 46 | 11.0 | 230 | 82 | 136 | 1.26 |
| Average | 491 | 49 | 44 | 4.9 | 101 | 75 | 66 | 0.73 |

New Compressors

| | | | | | | | | |
|----------------|-----|----|----|------|-----|----|-----------|-------------|
| Minimum | 438 | 44 | 39 | 1.2 | 23 | 67 | 16 | 0.36 |
| Maximum | 494 | 59 | 52 | 11.3 | 224 | 86 | 166 | 0.77 |
| Average | 469 | 50 | 45 | 5.5 | 108 | 72 | 56 | 0.49 |



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Retrofit Cost in San Diego

| | |
|--|-----------------|
| Design | \$10,259 |
| Installation Planning and Procurement | \$4,529 |
| Chiller Purchase | \$33,000 |
| Mechanical Subcontractor (for chiller) | \$95,690 |
| Controls Subcontractor (for chiller) | \$7,550 |
| Controls Subcontractor (for misc. items) | \$16,140 |
| Installation Management | <u>\$11,519</u> |
| | \$178,687 |



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2 ea. 60 ton chiller compressors with magnetic bearings

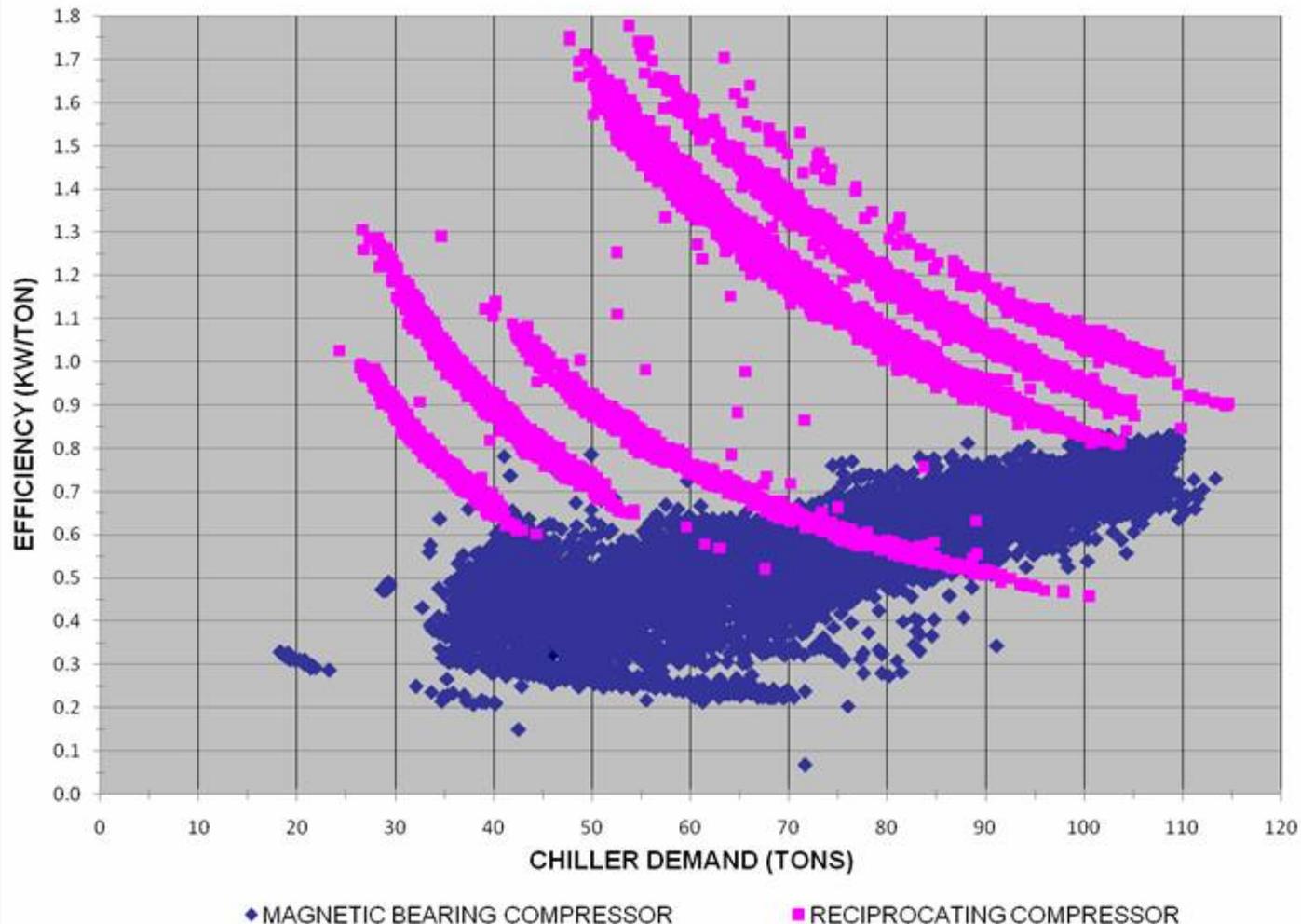
NAS Jacksonville FL





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MAGNETIC BEARING VS. RECIPROCATING COMPRESSORS
COMPRESSOR EFFICIENCY



Paul Kistler

August 9-12, 2009



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JAX Data

| | Compressor Efficacy | Plant Efficacy | Average Load | Average Compressor Power | Cooling Tower Power | Plant Power |
|----------|---------------------|----------------|--------------|--------------------------|---------------------|-------------|
| New | .57 kW/ton | .61 kW/ton | 75.4 ton | 45.9kW | 2.44kW | 48.3 kW |
| Existing | 1.02 kW/ton | 1.04 kW/ton | 76.7 ton | 78.5kW | 1.55kW | 80.1 kW |



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Cost for installation in Jacksonville

| | |
|---|-----------------|
| Mechanical Subcontractor (including compressor) | \$95,150 |
| DDC Subcontractor | <u>\$12,442</u> |
| Total | \$107,592 |



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The Table below presents a synopsis of the data collected for these three projects:

| Project Site | Project Type | \$/KWH | Tons | Annual kWh savings | Annual Energy \$ Savings | % Savings | Cost | \$/Ton | Payback (years) |
|-----------------------|--|---------|------|--------------------|--------------------------|-----------|-----------|--------|-----------------|
| San Diego 2006 | Add 3 rd compressor | \$0.121 | 240 | 176,717 | \$21,206 | 40% | \$178,787 | \$744 | 8.4 |
| Newport Sep/Nov 2005 | New Chiller | \$0.115 | 80 | 227,760 | \$26,192 | 65% | \$100,783 | \$1260 | 3.8 |
| JAX Dec/Apr 2006/2007 | Compressor Retrofit with Cond. Water reset | \$0.054 | 120 | 284,407 | \$15,358 | 41% | \$107,592 | \$897 | 7.0 |



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The Table below is the simple payback using the incremental cost:

| Project Site | Tons | Annual Energy \$ Savings | Incremental Cost | Payback (years) |
|----------------------|------|--------------------------|------------------|-----------------|
| San Diego 2006 | 240 | \$21,206 | \$24,000 | <u>1.1</u> |
| Newport Sep/Nov 2005 | 80 | \$26,192 | \$8,000 | <u>0.3</u> |
| JAX 2006/2007 | 120 | \$15,358 | \$12,000 | <u>0.8</u> |



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Maintenance

1. Quarterly tightening of terminal screws (could be done in conjunction with #2 once per year) 2 work-hours per service
2. Annual blowing dust off circuit boards 2 work-hours per service
3. Change capacitors every five years 8 work-hours per service plus \$250 for capacitors

Over 10 years that would be 96 work-hours plus \$500 for capacitors.



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Other advantages of the compressor

- **Quiet** – In San Diego the chilled water pumps make more noise than the chiller. Could be a plus if installation is in an area where noise is an issue.
- **Light weight** – If compressor needs to be changed out, can be accomplished manually by two persons.
- **Low startup draw** – about 2 amps. Could be a plus if you are replacing or installing a backup generator since generator can be downsized to handle full load draw, not startup. Smaller generator may pay for incremental cost of compressor.



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Problems

Newport

- Thermister failed. Thermister was replaced and problem has not recurred.
- Automatic Expansion Valve not tuned properly. Valve was adjusted and problem has not recurred.

San Diego

- Insulated Gate Bipolar Transistor (IGBT) failed. Decision was made to replace compressor since it was relatively easy to do. Replacement took two hours. Problem has not recurred.
- Power surge damaged one of three compressors. Compressor was replaced. Manufacturer has stated that electronics have been improved since this compressor was installed.
- Electronics were not sealed sufficiently resulting in moisture damage. Sealing has been improved.

Jacksonville

- None



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Best Places To Install Magnetic Bearing Chiller Compressors

- Relatively high electric rates ($> \$0.06$ kWh)
- Long run hours at part load
- Where existing compressor is in need of replacement



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