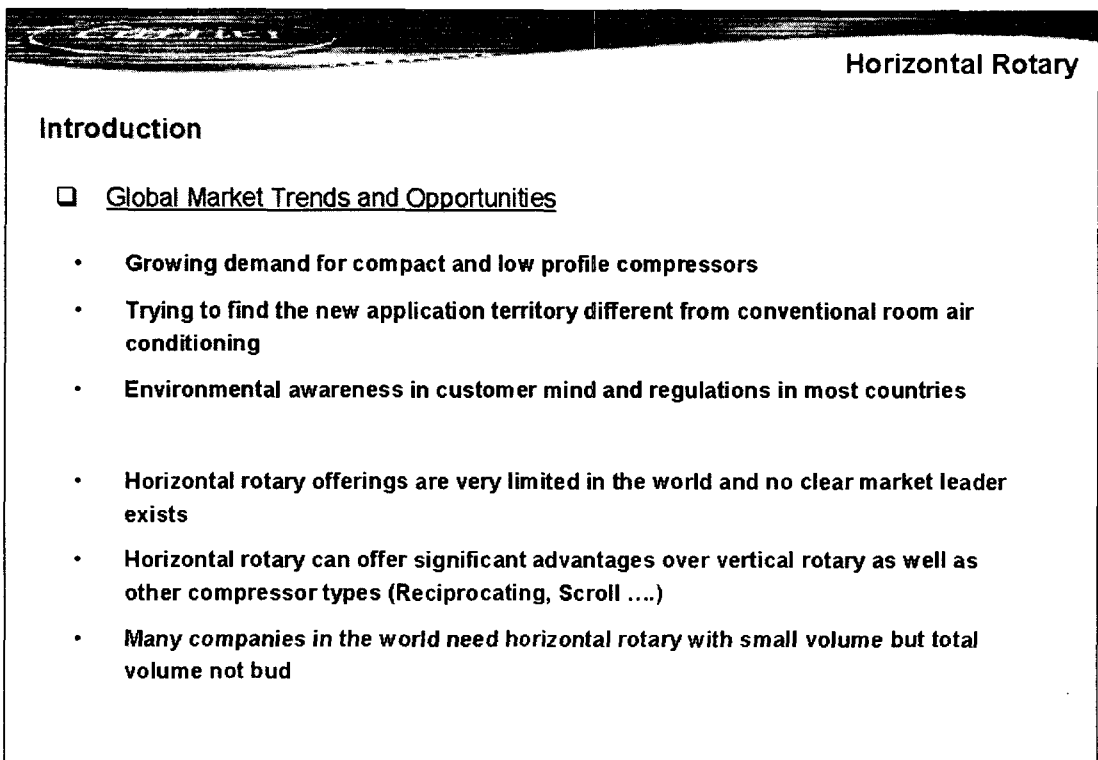


**“The Horizontal Rotary Compressor
using Alternative Refrigerants”**

December 5, '2003

**By
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- Introduction
 - Market Trends and Opportunities
 - Market Potential
- Horizontal Design Guide
 - Considerations in Design
 - Operating Envelope
 - Oil Pump Mechanism
 - Allowable Inclination Angle
 - Torsional Vibration
- Horizontal Rotary Design (CKO)
 - Technical Approaches
 - Appearance and Dimensions
- Overview
- References



Horizontal Rotary

Introduction

- Global Market Trends and Opportunities
 - Growing demand for compact and low profile compressors
 - Trying to find the new application territory different from conventional room air conditioning
 - Environmental awareness in customer mind and regulations in most countries

 - Horizontal rotary offerings are very limited in the world and no clear market leader exists
 - Horizontal rotary can offer significant advantages over vertical rotary as well as other compressor types (Reciprocating, Scroll ...)
 - Many companies in the world need horizontal rotary with small volume but total volume not bud

Introduction

Market Potential for Alternative Horizontal Rotary

<u>Application</u>	<u>Refrigerants</u>	<u>Prospect</u>
• Refrigerator	R134a	Not Hopeful
• Refrigeration		Hopeful / Volume Limited
Show Case	R404A / R134a	Growing
Refrigeration Unit	R404A / R134a	Growing
Vehicle	R134a	Growing
• Air-Conditioning		
Residential	R407C (R410A)	Not Hopeful
Vehicle	R407C (R410A)	Volume Limited

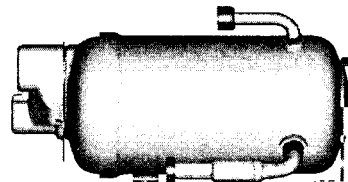
Note) Growing potential market seems to be mainly for refrigeration application

Horizontal Design Guide

Considerations in Horizontal Rotary Design

- Operating Envelope according to Refrigerants
- Oil Pump Mechanism for Lubrication
- Allowable Inclination Angle
- Torsional Vibration
- **Mounting Method**
- **Control Oil Level**
- **Control Oil Circulation Rate**
- **System Piping Design**
- **Maximum Refrigerant Charge**
- **Startability at On-Off Cycling Condition**
- **System Auxiliary Accumulator**

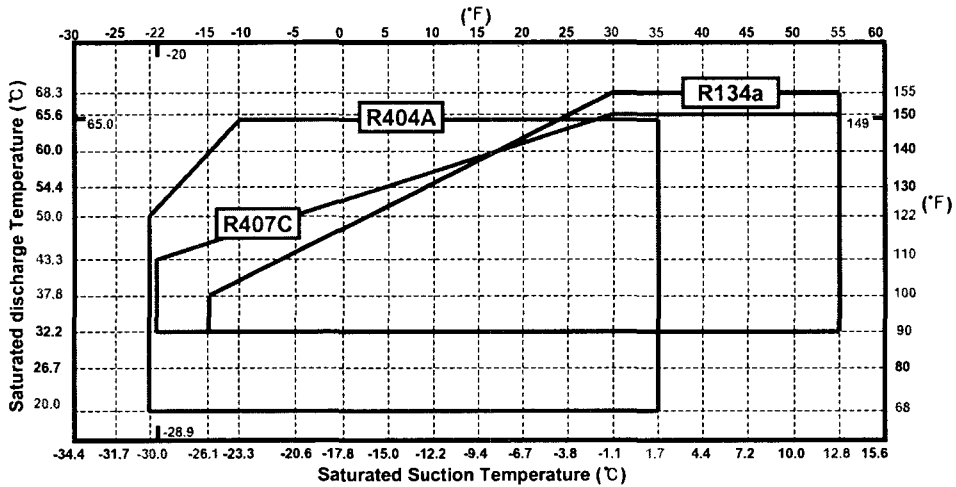
Four Items will be Addressed in this Paper



Horizontal Design Guide

Operating Envelope

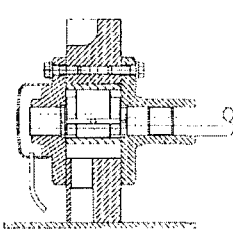
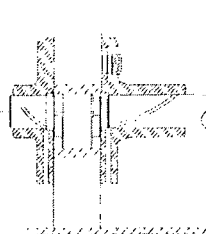
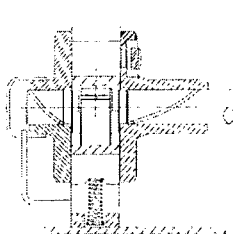
The operating envelope according to refrigerants is shown in below. This represents the range for steady state operation. Under transient conditions such as start-up and defrost(for heat pump applications) the compressor may operate outside this envelope for short periods.



Horizontal Design Guide

Oil Pump Mechanism

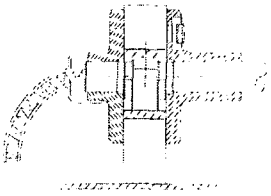
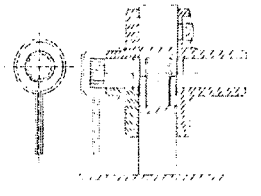
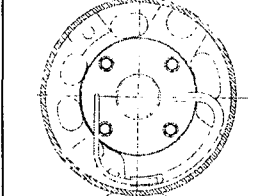
Several oil pump mechanism for horizontal have been adopted at each compressor makers as below :

Oil Pump	Centrifugal Rotor Fan	Pressure Difference through Bearing	Vane Pump
Mechanism			
Description	Excellent from the viewpoint of pump system reliability and cost saving	Simplest method but fabrication cost up	Reliable but need additional parts and cost
Maker	ROTEX and CKO	MELCO	TOSHIBA and HITACHI
Application	High Back / Low Back	Low Back	High Back / Low Back

Horizontal Design Guide

□ Oil Pump Mechanism (Cont'd)

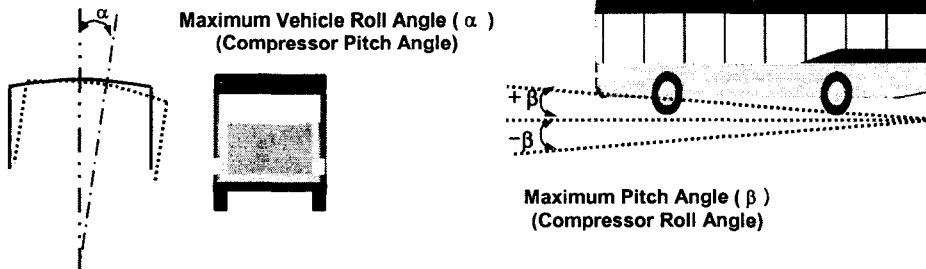
Several oil pump mechanism for horizontal have been adopted at each compressor makers as below :

Oil Pump	Spring Pump (Elephant Nose)	Gear Pump	Discharge Gas Injection Pump
Mechanism			
Description	After epidemic failure in refrigerator, discontinued to use this method	Most popular and reliable but expensive pump	Simplest but poor lubrication due to oil and refrigerant mixture
Maker	MATSUSHITA	MATSUSHITA AND HITACHI	MITSUBISHI
Application	Low Back	High Back / Low Back	Low Back

Horizontal Design Guide

□ Allowable Inclination Angle for Vehicle Application

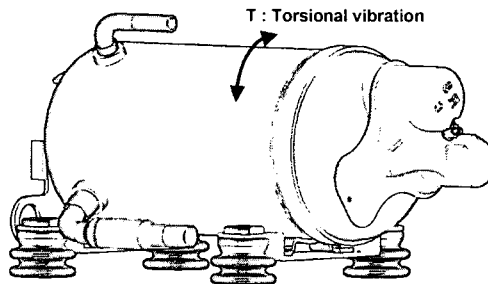
- Vehicle roll and pitch angle means compressor pitch and roll angle depending on installation direction, in worst case, the position of pump side is higher than motor side. Horizontal rotary should secure the oil feeding and oil level maintenance with required pitch and roll angle of vehicle



Horizontal Design Guide

□ Torsional Vibration

- Horizontal rotary compressor has a rotating crankshaft driven horizontally by motor. Therefore, torsional vibration is also larger than tangential vibration. The mounting method on horizontal is different from vertical. Horizontal rotary is commonly mounted at 4 positions at each end of shell as shown in below while vertical at 3 points only at lower shell side.



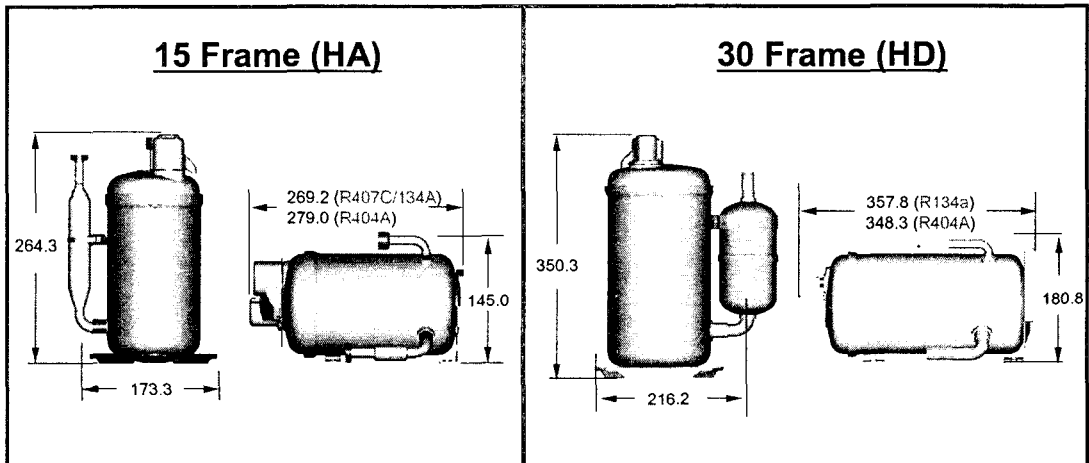
Horizontal Rotary Design (CKO)

□ Technical Approaches

- Conduct analytical and experimental study on oil feeding system to make sure the sufficient oil supply into moving parts in a wide range of operating conditions
- Perform road vibration test under Environmental Military Standard (Mil-Std-810D) for both hard and soft mounting to simulate the field circumstances
- Experiment on allowable inclination angle in accordance with maximum side-to-side and fore-and-after movement of vehicle
- Install some oil separation apparatus to reduce OCR(Oil Circulation Rate) and verify the optimum oil charging amount
- Monitor oil level through sight glass at several severe operating conditions with unit and confirm the stability of oil level during running

Horizontal Rotary Design (CKO)

□ Exterior Appearance and Physical Dimensions



- **Frame means motor diameter (or motor size) in compressor shell and larger frame can cover larger capacity**

Overview

- **Optimization in the basic design and continuing reliability improvement study of horizontal rotary ascertain the replacement HCFC refrigerants with HFC refrigerants**
- **Because of productivity drop, horizontal rotary costs more than vertical rotary in material, labor and manufacturing efficiency. However, it can offer substantial advantages against other types of compressor**
- **Addressing the requirement of system in accordance with various applications and careful market research by country and by customer can extend the market and lead this market**

References

- Masao Ozu, "Application Guide Book", 2001
- Sinkyu Park, " Horizontal Rotary Compressor Development for Vehicle Refrigeration ", Final Report, 2002