



Efficient and sustainable container refrigeration applications using CO₂ NaturaLINE™ Unit Field Trial Results

INTRODUCTION



Previously at ATMOSphere 2011

Carrier announced NaturaLINE technology for transport refrigeration & start of field trial

Recommended inclusion of transport refrigeration in EU regulations and phase out of HFC's by 2025

December 2011 Carrier introduced NaturaLINE technology at Intermodal Europe, Hamburg

ATMOSphere Europe 2012 - update field trial and training initiative results

CO₂ PRODUCT DESIGN INTRODUCTION



REFRIGERATED CONTAINER SHIPPING

**NaturaLINE
refrigeration machine
(reefer)**



**Mated to ISO insulated containers
(20' or 40'-long)**



**Transports virtually
all perishable and
frozen cargoes**



EFFICIENCY IMPERITIVE



Global refrigerated trade growth 5%¹

Container ships and roll-on/roll-off ships carry 60% of the goods by value moved internationally by sea.²

International maritime shipping accounts for 870 million tonnes, about 2.7 percent of annual global greenhouse gas emissions in 2007.³

IMO adopts mandatory technical and operational energy efficiency measures to reduce greenhouse gas emissions from ships; Revision to MARPOL Annex VI expected to enter into force on 1 January 2013.⁴

Improving efficiency and reducing emissions vital as shipping continues to grow.

1. M. Slagen, Seabury Group, Recession proof reefer trade?, Cool Logistics 2012

2. World Shipping Organization, September 2009

3. Second IMO Greenhouse Gas Study, 2009

4. IMO Marine Environment Protection Committee (MEPC) – 62nd session: July 2011

CONTINUOUS IMPROVEMENTS

Reduce GWP

Direct

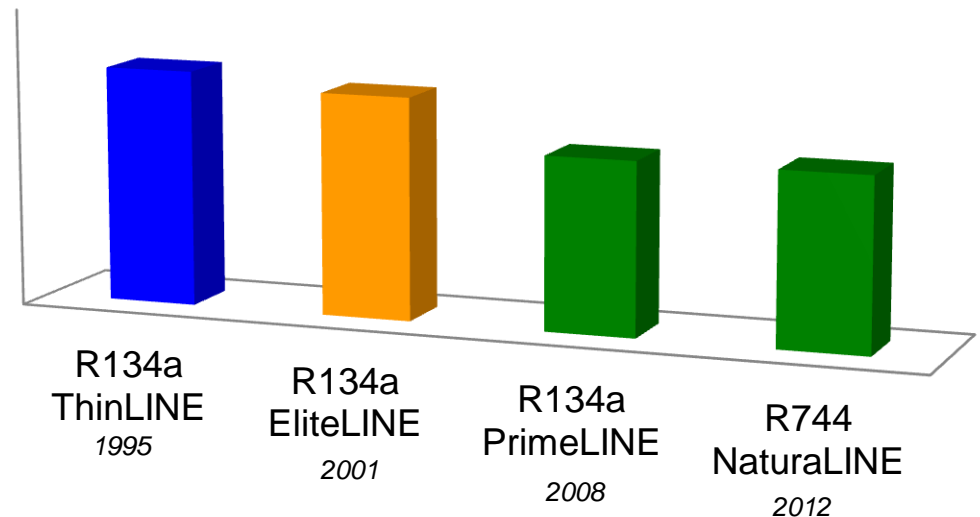
Indirect

Reduce carbon footprint

Production processes

Materials

Average energy consumption



Source : Carrier estimates

CO₂ NEW TECHNOLOGY



Purpose built multi-stage compressor



Gas cooler heat exchanger



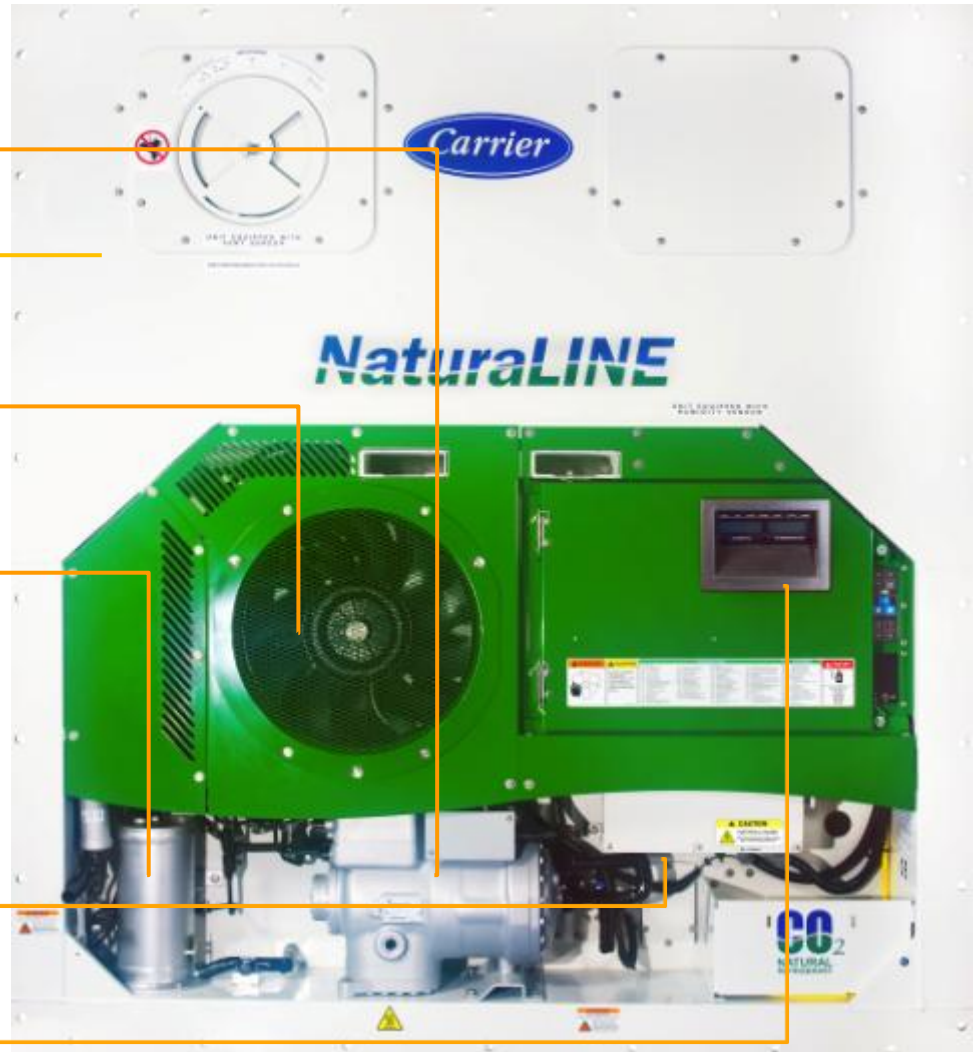
Flash tank



Variable speed drive



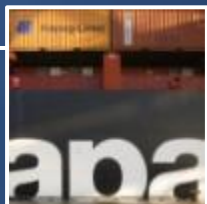
Advance software and controls



2012 EXPANDED SEA TRIALS



Reefer Container



Hapag-Lloyd AG
Requirements New Refrigerant
Trial - Results

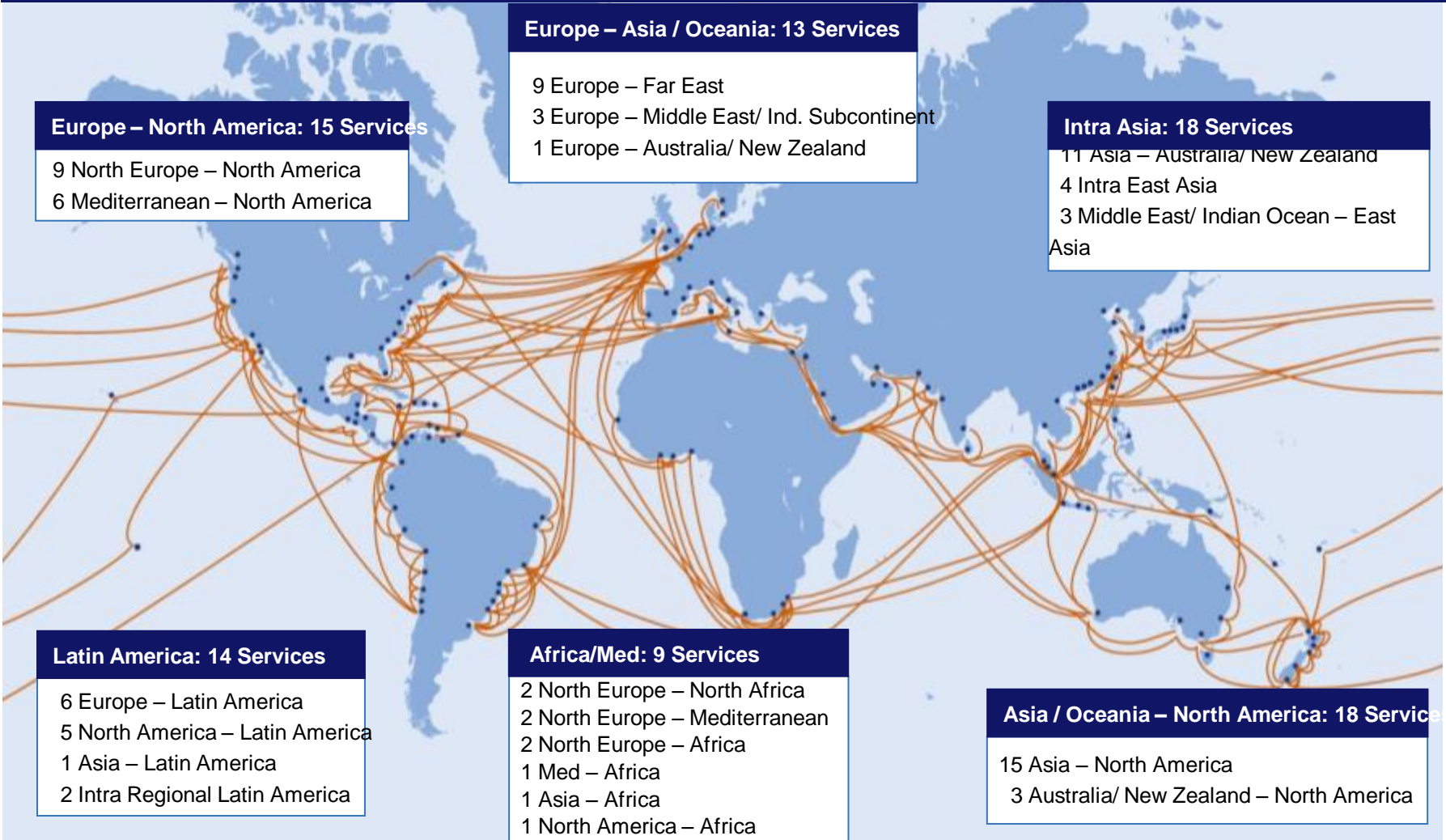


Hapag-Lloyd at a Glance

- One of the leading global container shipping companies
- Extensive service network with 87 services around the globe
- 138* modern container vessels with a capacity of about ~621,000 TEU and more than 1.0 million containers (TEU) of various types
- Global presence with about 300 sales offices in 114 countries
- Employees: ~6,900



87 Services around the Globe





Container Fleet of more than 660.000 Containers

Large Variety



General Purpose
High Cube
Hard Top



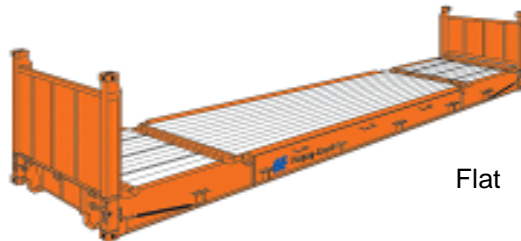
Open Top



Ventilated



Reefer



Flat



Platform



Thereof 40.000 Refrigerated Containers



HLXU 374 083 0
22R1



Hapag-Lloyd



Requirements

- Best-in-class performance
 - Power consumption
 - Performance
 - Pull down capacity
 - Temperature control
 - Reliability
 - Serviceability

Better or at least meeting the criteria of the units available today

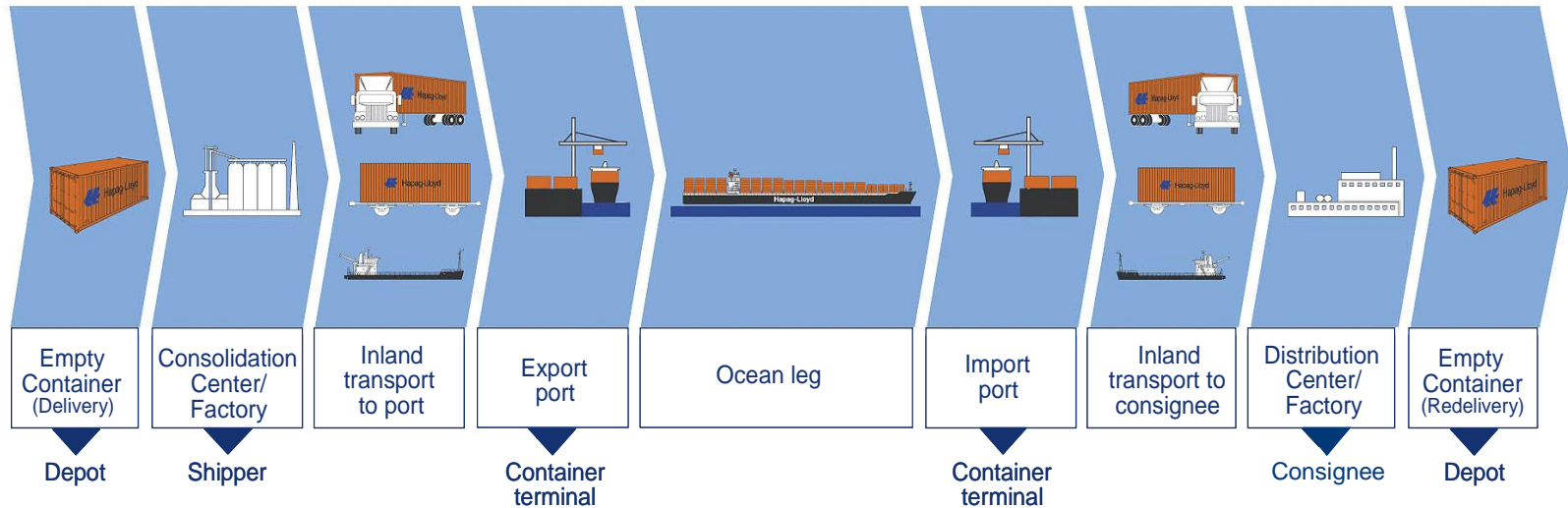


Refrigerants

- + Long-term deployable
- + No Flame Propagation
- + Low Toxicity
- + No interim solution
- + Worldwide availability
- + GWP 1
- + Serviceable



= CO₂



Technical Goals

- Demonstrate concept / design feasibility
- Gain valuable insight & data with test trial
- Introduce service personnel to technology
- Gain valuable field data and experience

2012: Field Trial

- Invite customer to participate
- Select variety of cargo
- Select variety of trades
- Get feedback from field engineers
- Get feedback from vessel crews



Field Trial

Result

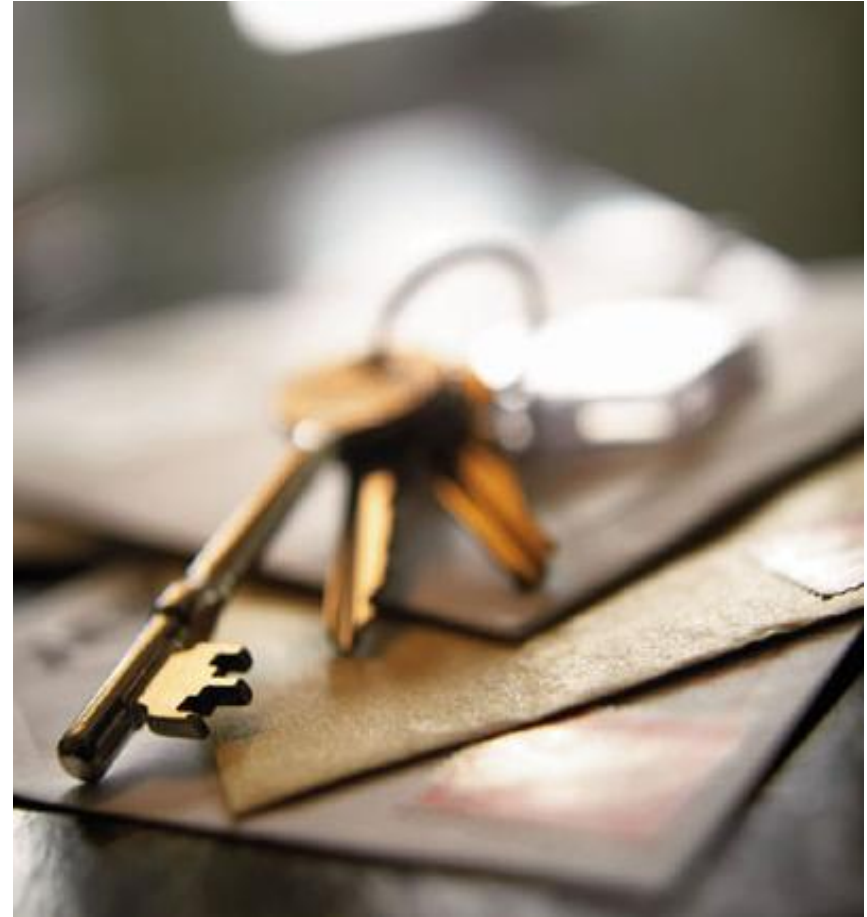
- All ambients = **OK** ✓
- Maintain frozen & perishable set points up to 32 C (90 F) = **OK** ✓
- Design life multiple voyages = **OK** ✓
- Carrier CO2 compressor designed for container application = **OK** ✓
- Training worldwide = **to be continued** !



Summary

New Hardware and Technology should proven to be

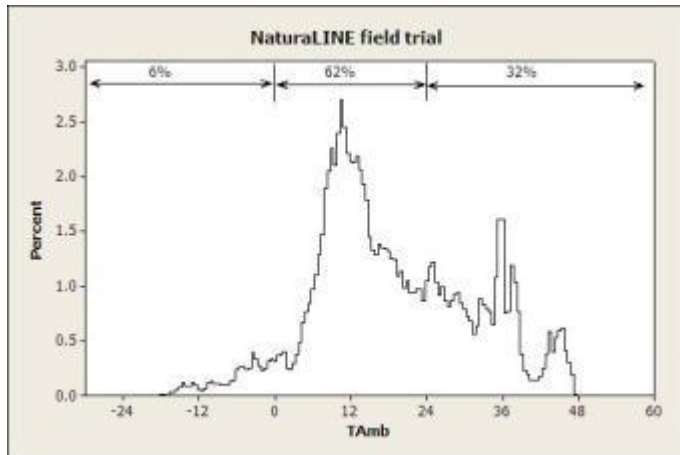
- **Reliable**
- **Environmentally sound**
- **Robust**
- **Long-term deployable**



NaturaLINE SEA TRIALS

Trans-critical results

Global ambient temperature exposure

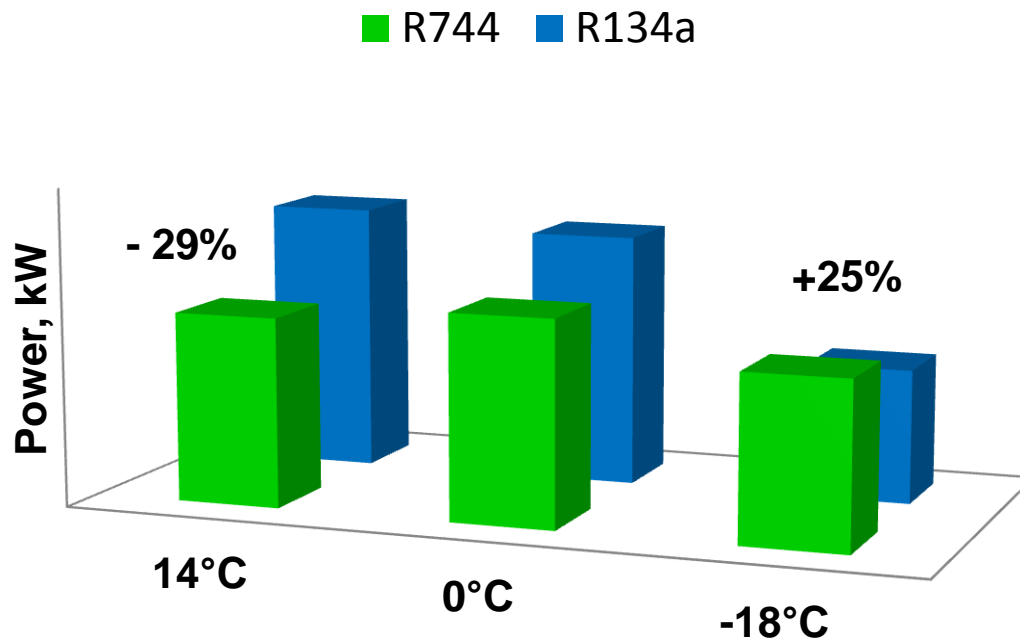


Maintain frozen & perishable set points



NaturaLINE SEA TRIALS

Energy consumption results

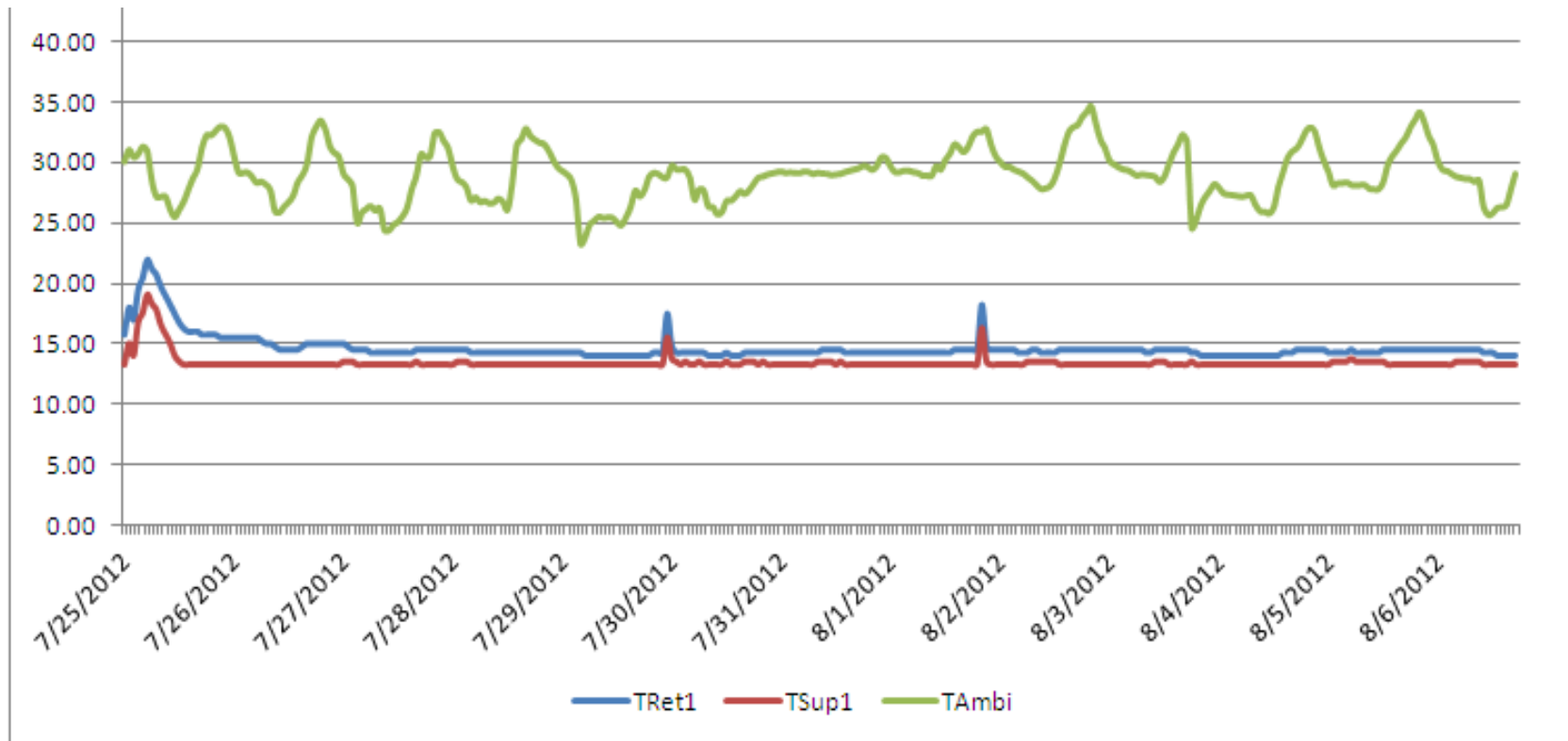


Typical control temperatures

Average energy use
equal to R134a

NaturaLINE SEA TRIALS

Trans-critical results – perishable set point



NaturaLINE SERVICE TRAINING

Global container training initiative

Training schools – on regular training schedule

Service Center training – 183 technicians trained

Vessel crew training – 12 vessels

Training content

- Fundamentals of Refrigeration (R134a and R744)

- Working with pressure and high voltage

- Operation of NaturaLINE unit

- Servicing and trouble shooting



SUMMARY

Successful 2012 field trial results, continue to expand on those successful results

Component suppliers filling gaps

OEMs expanding R744 products

Continuing industry concerns of non-natural solutions

GWP = 1

Minimize environmental impact

Improve energy efficiency





Thank you very much for your consideration
and your support.