• We Provide:
  – Hanhe HV EPR Cable with G&W Accessories
  – Products Fully System Tested
  – Hanhe HV Cable Systems to 500kv, AC or DC

• The Following Slides are an Overview of the Hanhe Cable products and facilities
• For full data on G&W and Hanhe Systems, Call us!
Hanhe Cable Introduction
1. Quick Facts

Employment Size
- Qingdao Corporate Office - 1,780
- Subsidiary - 1,000
- Manufacturing Plant - 7

Milestone
- 1982: Started as Qingdao Laoshan Copper & Aluminum Plant
- 1997: Renamed Qingdao Hanhe Cable Group Company
- 2007: Renamed Qingdao Hanhe Cable Co., Ltd
- 2010: IPO & stock listed in Shenzhen (002498)
1. Quick Facts

State Of Business:

Total assets - $813 million

2016 Financials at a glance - $67 million net profits after $27.4 million paid in taxes on total sales revenue of $943 million
1. Quick Facts

7 categories, more than 4,000 varieties and 20,000 specs. We can provide our customers with cable supplies and turnkey engineering solutions.

Main products: Power Cable, Submarine Cable, Mining Cable, Overhead conductors, Cable Accessories, Online Monitor Devices.

**HV XLPE cable**
Up to 5000kcmil 500kV AC and 320kV DC. Meets AEIC, ICEA, and IEC Standards.

**Submarine Cable**
Up to 500kV in AC and DC
Fiber optical imbedded

**HV EPR Cable**
Up to 138kV

**Overhead Conductors**
High temperature resistant and large capacity transmission due to alloying and thermal treatment

**69-500kV XLPE Cable**
Accessories
Increases the reliability of power supplies by using non mold seam technology
1. Quick Facts

R&D Credentials:

• Qingdao Cable Research Center
• National Enterprise Technology Center
• Post-Doctoral Research Center
• National HV and EHV Cable Technology Research Center
2. Development

History:
1. 110kV XLPE Cable: First test run - 1995, Production - 1998
2. 220kV XLPE Cable: First test run - 1999, Production - 2002
3. 500kV XLPE Cable: First test run - 2003, Type tested - 2005, Production: 2012
4. 110kV XLPE Cable Accessories - 2007
5. 220kV XLPE Cable Accessories - 2011
6. 500kV XLPE Cable Accessories - 2011
2. Development

Two VCV Towers with six vertical production lines
2. Development

Submarine Factory

Location: Neighboring the Nvdao Pier (level 2) at Jimo City, Qingdao. 6 meter draught. Hanhe can deliver the cable directly from the pier to large transport vessels.

Covered area: 34,000 m²
2. Development

Hanhe Cable Achievements:

Hanhe Cable has finished more than 100 submarine cable projects since 1998 and the total length of submarine cable provided by Hanhe has exceeded 2,000 miles. We are able to provide single conductor, 3-conductor and optical fiber composite cable. We use XLPE/EPR insulation and our waterproof layer is made of Aluminum (Copper) Plastic Composite Tape or Lead Sheath. We have passed the product identification of 110kV, 220kV and 500kV submarine cable.
Submarine Cable Manufacturing

Submarine Cable Armoring Production Line

Main Technical Parameter
- Diameter of single wire: Φ138mm
- Maximum Cable OD: Φ300mm
- Maximum Armored Cable OD: Φ330mm
- Vertical Stranding Cage Rated Speed: 2.5r/min
- Vertical Stranding Cage Motor Drive System: 160kw(DC), one
- Cable Interval: 500 ~ 8000mm
- Traction Method: 1+2: Six Traction
- Maximum Traction Force: 6 tons+20 tons×2
- Maximum Traction Speed: 20m/min
Submarine Cable Manufacturing

New VCV production line

Cable tray configuration:
Φ8000×3+Φ3150×3

Large cable tray configuration:
Φ8000×Φ3000×2500
Maximum load: 300 tons

Small cable tray configuration:
Φ3150×Φ1900×2300
Maximum load: 30 tons
Submarine Cable Manufacturing

Steel wire armoring machine configuration:
(Φ1400/2+70/Φ630)+ 80/Φ630 Cage strand steel wire armoring machine

- Steel wire maximum OD: bullet wire: Φ5.0mm
- mild steel wire: Φ8.0mm

- Cable tray spec in cage: PND630
- Fiber optic tray spec: 1400
- Maximum rated speed: 20r/min
- Armoring interval: 300 ~ 3600mm
- Steel wire paying-out tension: 50kg
Submarine Cable Manufacturing

Equipment and Load Capacity of Finished Cable

• Extrusive insulated conductor:
  Load Capacity for 10m diameter tray:
  35kV 95mm², 132km. 220kV 2500mm², 12km

• Conductor with lead extrusion and sheath:
  Load Capacity for 12m diameter tray:
  35kV 95mm², 120km. 220kV 2500mm², 12km

• Cabling machine tray:
  Load Capacity for 8m diameter tray:
  35kV 95mm², 48km. 220kV 2500mm², 5km.

• Finished cable:
  Load Capacity for 30m diameter tray:
  35kV 3×95mm², 123km
  220kV 1×2500mm², 61km, 3×2500mm², 14km
Submarine Cable Manufacturing

Insulated Conductor Tray

10m diameter tray
Submarine Cable Manufacturing

Cable conductor tray

12m diameter tray
Submarine Cable Manufacturing

Finished cable tray

30m diameter tray
Packing
Upcoming...

New VCV Submarine Cable Production Tower

Tower Height: 450 ft
Max Voltage: 750 kV(AC), 500kV(DC)
Max Conductors Size: 7000 kcmil
Extension pre-qualification testing program for 230 kV cable system with US temperature requirements.
Industry Requirements

- IEC 62067 – system standard for 230 kV and up
- Calls for 1-yr PQ test or EPQ test:

  - **Cable Manufacturer A**
    - 1-yr pre-qualification test
    - A

  - **Accessories Manufacturer B**
    - 1-yr pre-qualification test
    - B

  - Extension PQ test

  - A + B
Customized test program

• **AEIC CS9** – US utility specification adopts IEC approach for 230 kV but requires US temperatures 100° C – 105°C

• **Objective** – customized test program to qualify:
  – 230 kV cable system per **AEIC CS9** (and IEC 62067)
  – Cable per **ICEA S-108-720**
  – **US temperature requirements and higher voltages**

• **Customized test program:**
  – 90 cycles at 105°C – 110°C with cable in a pipe
  – Higher test voltages for PD, AC and load cycling tests
  – Largest conductor size
  – High electrical stresses at conductor and insulation screens
KEMA INSPECTION REPORT

3120-16

Object     Single-core power cable
            132/300 [MV] 3X LSFH · CUKN · XLPE

Client     Guangdong Hanye Cable Co., Ltd.
            Guangzhou, China

Manufacturer Guangdong Hanye Cable Co., Ltd.
            Guangzhou, China

Inspected by DNV-GL Netherlands B.V
            Amsterdam, the Netherlands

Test location Shanghai National Center of Testing and Inspection for Electric Cable and Wire
            Co., Ltd (TCUC)
            Shanghai, China

Date of tests 21 April to 2 December 2016

Test specification The tests have been carried out in accordance with IEC 60840:2012.

Regarding Types Tests

Summary and conclusion The object has been tested in accordance with the relevant requirements of the standards.

This report applies only to the object tested. The responsibility for conformity of any object having the same type reference as that tested rests with the Manufacturer.

This report consists of 67 pages in total.

KEMA Laboratories

[Signatures]

12/18/2017

KEMA Inspection Report

3130-16

Object     Power cable system consisting of 5-core power cable, 4 terminations and 2
            poles
            132/300 [MV] 4X LSFH · CUKN · XLPE

Client Guangdong Hanye Cable Co., Ltd.
            Guangzhou, China

Manufacturer Guangdong Hanye Cable Co., Ltd.
            Guangzhou, China

Inspected by DNV-GL Netherlands B.V
            Amsterdam, the Netherlands

Test location Shanghai National Center of Testing and Inspection for Electric Cable and Wire
            Co., Ltd (TCUC)
            Shanghai, China

Date of tests 21 April to 2 December 2016

Test specification The tests have been carried out in accordance with IEEE C50-11 and IEC 60287
            (2011).

Regarding Tests for the evaluation of the prequalification of a cable system

Summary and conclusion The object has been tested in accordance with the relevant requirements of the standard.

This report applies only to the object tested. The responsibility for conformity of any object having the same type reference as that tested rests with the Manufacturer.

This report consists of 69 pages in total.
Results and conclusion

- Tests successfully completed in September, including Annex G for submersible joints
- Additional tests per ICEA S-108-720 included in the program
- Reports from two independent HV labs
- More coordination between relevant standards is desired
- 105° C – 110°C: tough but doable!
- Component approach – performance of a cable system is as good (or bad) as its weakest link
- Robust design margins of components per US requirements may be the feasible way forward
500kV IEC/GB PQ Test

1. Standards:
   - **GB/T 22078-2008** - Power cables with cross-linked polyethylene insulation and their accessories for rated voltage of 500 kV (Um= 550kV)
   - **IEC 62067** - Power cables with extruded insulation and their accessories for rated voltages above 150kV (Um=170kV) up to 500kV (Um=550kV)
   - **NFC 33—253** - Insulated Cables For Power Systems, Single-core Cables With Polymeric Insulation For Rated Voltages Above 150 kV (um = 170 kV) Up To 500 kV (um = 525 kV)
2. Insulation:

Rated voltage ($U_0/U$): 290kV/

500kV

Highest voltage for equipment ($U_{m}$):

550kV Voltage test:

580kV

Impulse lightning voltage test: 1,550kV (1,675kV)

Switching impulse voltage test: 1,175kV (1,240kV)
3. Design Of Cable:

- In accordance to IEC 60228 standard
- Conductor screen: Super smooth XLPE semi-conductive material
- Insulation: Super clean XLPE semi-conductive material
- Insulation screen: Super smooth XLPE semi-conductive material
- Buffer layer: Non-woven conductive band
- Metal sheath: Aluminum, copper or stainless material
- Serving: PVC(ST2) or PE(ST7)

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Copper Conductor</td>
</tr>
<tr>
<td>2</td>
<td>Conductor Screen</td>
</tr>
<tr>
<td>3</td>
<td>Insulation</td>
</tr>
<tr>
<td>4</td>
<td>Insulation Screen</td>
</tr>
<tr>
<td>5</td>
<td>Buffer Layer</td>
</tr>
<tr>
<td>6</td>
<td>Metal Sheath</td>
</tr>
<tr>
<td>7</td>
<td>Serving</td>
</tr>
</tbody>
</table>
4. Insulation thickness and electrical field grades:

<table>
<thead>
<tr>
<th>Section</th>
<th>Area</th>
<th>Thickness</th>
<th>Nominal Electrical Stress At Conductor Screen</th>
<th>Nominal Electrical Stress At Insulation Screen</th>
<th>Average Electrical Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>800</td>
<td>China</td>
<td>34</td>
<td>14.8</td>
<td>5.4</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>SIEMENS</td>
<td>30</td>
<td>16.0</td>
<td>6.3</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>27</td>
<td>17.2</td>
<td>7.2</td>
<td>10.7</td>
</tr>
<tr>
<td>1000.0</td>
<td>China</td>
<td>33</td>
<td>14.3</td>
<td>5.8</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>SIEMENS</td>
<td>30</td>
<td>15.3</td>
<td>6.5</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>27</td>
<td>16.4</td>
<td>7.4</td>
<td>10.7</td>
</tr>
<tr>
<td>1200.0</td>
<td>China</td>
<td>33</td>
<td>14.0</td>
<td>5.9</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>SIEMENS</td>
<td>30</td>
<td>14.9</td>
<td>6.6</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>27</td>
<td>16.0</td>
<td>7.5</td>
<td>10.7</td>
</tr>
<tr>
<td>1600.0</td>
<td>China</td>
<td>32</td>
<td>13.7</td>
<td>6.3</td>
<td>9.1</td>
</tr>
<tr>
<td></td>
<td>SIEMENS</td>
<td>30</td>
<td>14.4</td>
<td>6.8</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>27</td>
<td>15.5</td>
<td>7.7</td>
<td>10.7</td>
</tr>
<tr>
<td>1800.0</td>
<td>China</td>
<td>31</td>
<td>13.8</td>
<td>6.6</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>SIEMENS</td>
<td>30</td>
<td>14.1</td>
<td>6.9</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>27</td>
<td>15.3</td>
<td>7.8</td>
<td>10.7</td>
</tr>
<tr>
<td>2000.0</td>
<td>China</td>
<td>31</td>
<td>13.6</td>
<td>6.7</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>SIEMENS</td>
<td>30</td>
<td>13.9</td>
<td>7.0</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>27</td>
<td>15.0</td>
<td>7.9</td>
<td>10.7</td>
</tr>
<tr>
<td>2500.0</td>
<td>China</td>
<td>31</td>
<td>13.2</td>
<td>6.9</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>SIEMENS</td>
<td>30</td>
<td>13.6</td>
<td>7.1</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>27</td>
<td>14.7</td>
<td>8.1</td>
<td>10.7</td>
</tr>
</tbody>
</table>
500kV Cable Outdoor Termination:

Classified by External Insulation:
- Conventional porcelain type
- Composite polymer type

Classified by Internal Insulation:
- Silicon oil immersed capacitor cone
- Fluid insulated rubber stress cone

Classified by Pollution Degree:
Minimum creepage distance:
- Level I 16mm/kV
- Level II 20mm/kV
- Level III 25mm/kV
- Level IV 31mm/kV
500kV Cable GIS Termination:

Connecting Device:
- for GIS Switchgear
- for Transformer Structure
- Fluid Type Rubber Stress Cone
- Dry Type Rubber Stress Cone
500kV Cable Joint

Classified by connection type:
- Straight joint
- Insulated joint

Classified by insulation of joint:
- 3-piece prefabricated rubber insulation
- 1-piece pre-molded rubber insulation
Prequalification (PQ) Test: (PASSED, March 2013)

100 meters total length cable system including cable, joints, and terminations

**Total Test Time** - (Sep. 28, 2011 ~ Jan. 20, 2013) / 8,819.1 hrs., AC voltage of 493kV (1.7U0)

**Heat Cycles** - 182 times, applied without interval, heating-cooling cycle at 90-95 ℃ repeated.

**Impulse Lightning Voltage Test** - (10 times @ 1,550kV)

**Structural Inspection** - Passed
## Prequalification test on 500 kV 2500 mm² XLPE insulated power cable and accessories

**Manufacturer cable**
Cqingdao Hanhe Cable Co., Ltd.
Qingdao, Shandong, China

**Manufacturer accessories**
Viceps Corporation
Tokyo, Japan

### REQUIREMENTS

The requirements are as mentioned in the standard IEC 60502 (2011-11).

### TEST PROGRAMME

The programme consisted of all the prequalification tests as stated in IEC 60502 (2011-11). For this programme references to made to page 15.

### SUMMARY AND CONCLUSION

The test results obtained relate only to the work performed and to the material tested. The requirements for the prequalification test were met.

### Author

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li Rong</td>
<td>Director Testing</td>
<td>8 May 2014</td>
</tr>
</tbody>
</table>

**KEMA trademark by**

230kV AEIC and ICEA Test

500kV AC Underground Cable - Type Test
Meet AEIC, IEC and ICEA Standard
AEIC CS9 – US utility specification adopts IEC approach for 500 kV but requires US temperatures 100°C – 105°C
Objective – customized test program to qualify:
- 500 kV cable system per AEIC CS9 (and IEC 62067)
- Cable per ICEA S-108-720
- US temperature requirements and higher voltages

Customized test program:
- 20 cycles at 105°C – 110°C with cable in a pipe
- Higher test voltages for PD, AC and load cycling tests
- Largest conductor size
- High electrical stresses at conductor and insulation screens
500kV AC Submarine Cable PRE-Qualification Test
Major Projects
Case 1: Beijing 500kV Transmission Project

Double circuits, 500kV power cable (cross-section 2,500mm²), the route length is 21 km, comprising of 3 GIS terminations, 3 outdoor terminations, 33 joints. Cables were installed in tunnel.
Project Overview

❖ Cable System - with focus on 500kV transmission line
❖ Tunnel Construction
❖ On-site Cable system Testing
❖ Grid monitoring system & Safety
500kV Cable System

No. of Circuits: 2

Length: 21 km/13.2 miles

Cable: 2,500mm² / 5,000kcmil single core, segmental round, copper conductor, XLPE insulation

Rated voltage(Uo/U): 290kV/500kV

Accessories: 3 GIS terminations, 3 outdoor terminations, 33 joints per circuit

Standards: IEC 62067 & GB/T 22078-2008

<table>
<thead>
<tr>
<th>Structure</th>
<th>Thickness</th>
<th>OD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor</td>
<td>-</td>
<td>61.5±0.5</td>
</tr>
<tr>
<td>Conductor Screen</td>
<td>0.14</td>
<td>62.5±1.0</td>
</tr>
<tr>
<td>Insulation</td>
<td>2.0</td>
<td>66.5±1.0</td>
</tr>
<tr>
<td>Insulation Screen</td>
<td>31.0</td>
<td>128.6±1.5</td>
</tr>
<tr>
<td>Insulation Screen</td>
<td>1.5</td>
<td>131.5±1.5</td>
</tr>
<tr>
<td>Buffer Layer</td>
<td>Semi-conductive Butyl Band</td>
<td>1*0.25</td>
</tr>
<tr>
<td>Buffer Layer</td>
<td>Semi-conductive Waterproof Swellable Tape</td>
<td>4*2.0</td>
</tr>
<tr>
<td>Corrugated Aluminum Sheath</td>
<td>3.3</td>
<td>163.0±4.0</td>
</tr>
<tr>
<td>Outer Sheath</td>
<td>6.0</td>
<td>178.0±4.0</td>
</tr>
<tr>
<td>Outer Semi-conductive Layer</td>
<td>0.2</td>
<td>175.4±4.0</td>
</tr>
</tbody>
</table>
Beijing 500kV Transmission Project Type Of Shipping:

<table>
<thead>
<tr>
<th>Long (ft)</th>
<th>FD OD (ft)</th>
<th>TH Height (ft)</th>
<th>TW Weight (ft)</th>
<th>B ID (ft)</th>
<th>Empty weight (kg)</th>
<th>Total weight(*) (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>15.5</td>
<td>15.7</td>
<td>7.9</td>
<td>8.8</td>
<td>3800</td>
<td>26.7</td>
</tr>
</tbody>
</table>
Tunnel Construction

- Tunnel excavation using Ø 6m TBM. Total internal clearance of Ø 5.4m divided into four sections.
- Upper level - 220kV & 110kV circuits
- Lower lever - 500kV circuits
500kV Cable System Layout

- Transposed Cross-bonding configuration
- Vertical Snake
- Spacing between Anchor Cleat: 6 m
- Clamp Cleat: every 2 m
Comissioning Test

- AC Withstand test (Resonant Frequency, 20Hz ~ 300Hz)
  1.7U0 (493kV, 1 hour)
- PD Detection Test
Monitoring System, Safety Features, & Maintenance

❖ Smart Grid monitoring system
❖ EPON & Wi-Fi communication system
❖ Safety and Security
❖ Control Center
❖ Maintenance and Inspection Schedules
In 2014, the highest voltage level, the max single-side capacity largest multi-terminal HVDC flexible engineering - Zhejiang Zhoushan ± 200 kV demonstration project officially put into operation, ± 200kV, 71KM DC XLPE fiber –power composite submarine cables.
Thank you for your attention!