集肤效应系统
SKIN-EFFECT SYSTEM

集肤效应加热系统是用于长输管线的保温或防冻，它解决了单一电源供电时距离超过30km管线的保温难题，同时也是对多根长距离平行管道进行加热的最经济有效的办法。

集肤效应系统是一种安全可靠的加热系统，针对地面、地下和水下的长距离管道设计，包括需防爆的危险区域内的使用。

Induction-resistive heating system (IRHS) or Skin-Effect system is designed to maintain the product temperature, protect long trunk pipelines against freezing and ensure their start heating .Skin-system is the only one, which is capable to heat a pipeline run of up to 30km long with power supply from one point (without any parallel network); it is as well the most efficient and cost-effective solution for heating trunk pipelines of an unlimited length with parallel supply network.

Safe and reliable heating system for pipelines of an unlimited length designed for above-ground, buried and underwater pipelining, including ones in explosion.

- 是唯一一种可用于长度为30km以上管道伴热
  The only way to heat pipelines with the length up to 30km without parallel supply network
- 是一种最经济的加热长距离管道的方法
  The most efficient way to heat any trunk pipelines of an unlimited length
- 坚固的机械强度和可靠的系统设计
  Inherent strength and reliability of system design
- 加热元件的输出功率最大可以达到120W/m
  Up to 120 W/m power output of the heating element
- 获得GOST认证，可用于需防爆的危险区域内
  Certificate of conformity GOST (state standard) and permit of federal service for ecological, technological and atomic inspection for application in explosion hazardous zones
- 运行温度可高达200℃
  Operating temperature up to 200℃
- 加热管的外表面电势为0。通过接地，加热管上无需加装任何电气绝缘材料
  Zero electrical potential on outer surfaces of heating elements. After earthing and heating elements do not require any electrical insulation

工作原理
Principle of Operation

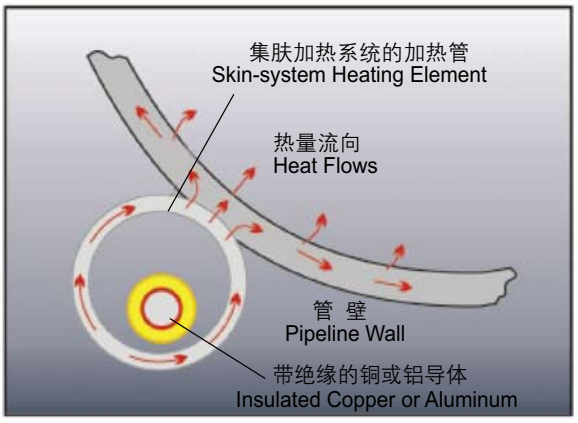
集肤效应加热系统是由一个外径20-60mm、厚度至少3mm的铁磁加热管及放置于管内的一个截面为10-50mm^{2}的铜芯或铝芯导体外加绝缘的电缆构成，在加热管的末端，导体与该加热管电气连接，交流电压加于导体与加热管的起始端，这样形成一个回路；电压的大小根据所需输出功率和加热回路的长度而定。

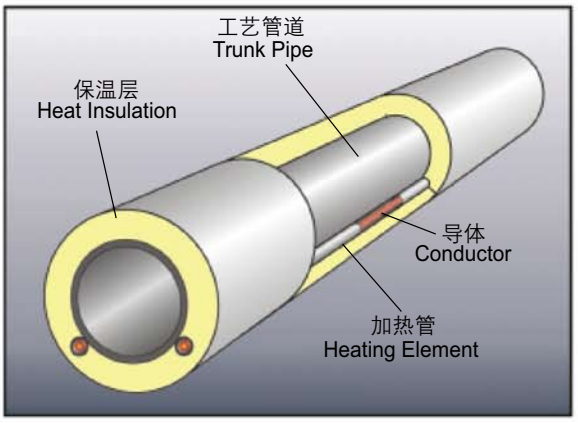
Heating element of the system consists of a ferromagnetic steel tube with the outer diameter of 20-60mm and the wall thickness of at least 3mm; there is an insulated copper or aluminum conductor with cross section of 10-50 mm^2 placed inside the tube.The conductor is electrically connected to the tube at the end of a heating run while AC voltage is supplied between the conductor and the pipe at the run head; the voltage value is calculated basing on the required heat output and the heated run length.

导体内的电流与加热管内的电流方向相反，因而产生集肤效应，其结果是：电流流经加热管的内层表面，而在加热管外层表面无任何电压降。

Currents of the conductor and the tube have opposite directions and thus skin and proximity effects originate in the system. As a result the tube current flows in the inner layer close to the inner surface of the tube and there is no voltage available on the outer surface of the tube.

导体不带有磁性（由铜、铝制成），因此，它不具有任何集肤效果，交流电流经整个导体截面，加热管提供80%的输出功率，因而是整个系统主要的能量来源。
The conductor is non-magnetic (made of copper, aluminum), thus, it does not feature any noticeable skin effect and AC flows throughout the whole section of the conductor. The main heat producing element of IRHS is the tube, which produces up to 80% of the system output.





优点
Advantage

■ 用于长距离管道加热：通过提高工作电压，单一电源供电的最大回路长度可达30Km。
Long range of a pipeline heated run：The system low resistance per a meter of length along with its high supply voltage makes possible to feed heated runs of up to 30km long from a single source.

■ 单端供电：集肤效应系统可设计成单端供电。
One end powering：The SKIN-system inherently is designed to be electrically supplied from one end of a heated run.

■ 电气安全：加热管的外表面接地因而它相对地面的电压降为零。
Electrical safety：Outer surface of the heating element is earthed and its voltage potential relative to the earth is zero.

■ 传热效果好：金属加热管被直接焊接在管道上或用特殊钢带固定在管道上。为了进一步提供传热效果，可加敷特殊的导热胶泥。
Good thermal contact：Metal heating element is welded directly to the pipeline or is fixed to it with special fasteners. In order to improve the thermal contact a special heat conducting paste is applied.

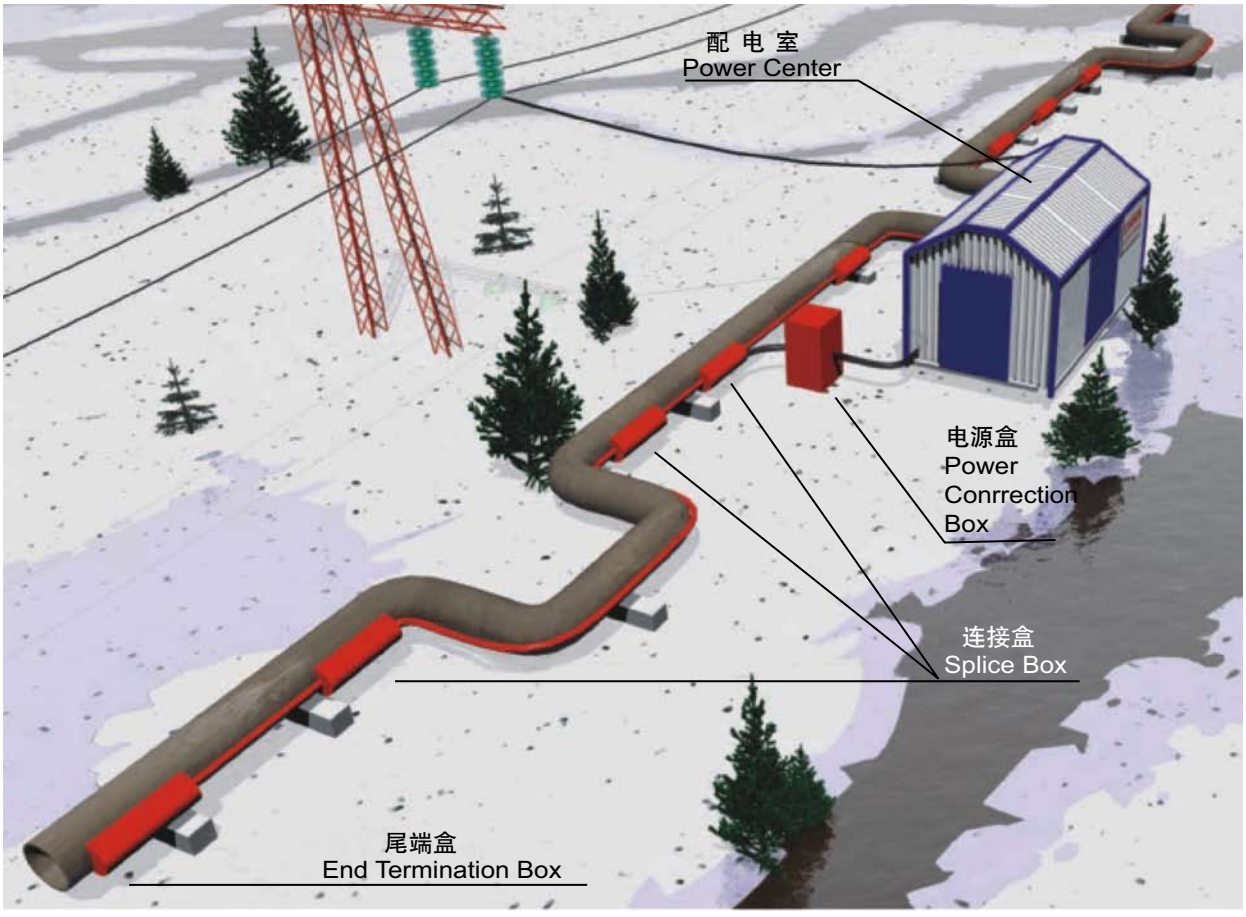
■ 安装简捷：供热管外不带有任何在安装过程中可能被损坏的外部电气绝缘材料。
Easy installation：Heat producing elements have not any outer electric insulation which may be damaged during installation works.

■ 可靠性高：铁质加热管可以保证导体承受任何机械损害，这对于埋地和水下管道非常重要。
Reliability：The steel heating tube ensures mechanical stability of the conductor and protects it against damages. This fact is especially important for buried and underwater pipelines.

■ 根据所需要的热量和工艺管道长度来决定采用1个、2个或3个加热管。
One, two or three heating elements can be fitted on a trunk pipe depending on the required heating power and pipeline length.

■ MICC 可根据用户要求来设计全套集肤效应系统，包括特殊的变压器，监控系统等。
MICC designs and supplies IRHS-system as a full set including a special integrated transformer substation, all elements belonging to the heating system itself, monitoring and control systems.

集肤效应加热系统的配电图
Electric Supply of a Pipeline Run Heated by Skin-effect System

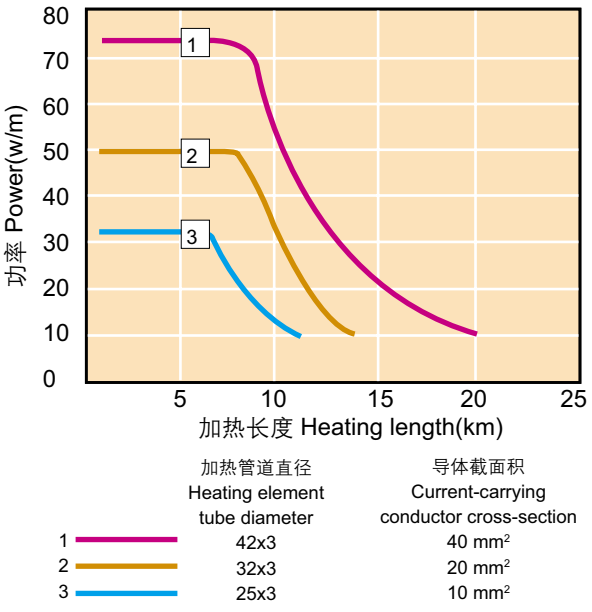


电源供电系统是由含高、低压端的变压器，特殊的负载平衡器和监控系统构成，整套系统安装于密封良好并带加热装置的配电房内。

Electric power supply system is performed as an integrated transformer substation including distributing sells of the HV and LV sides, specialized balancing transformer, monitoring and control system. The integrated power center is located in a hermetically sealed and heated container.

技术说明
Technical Specification

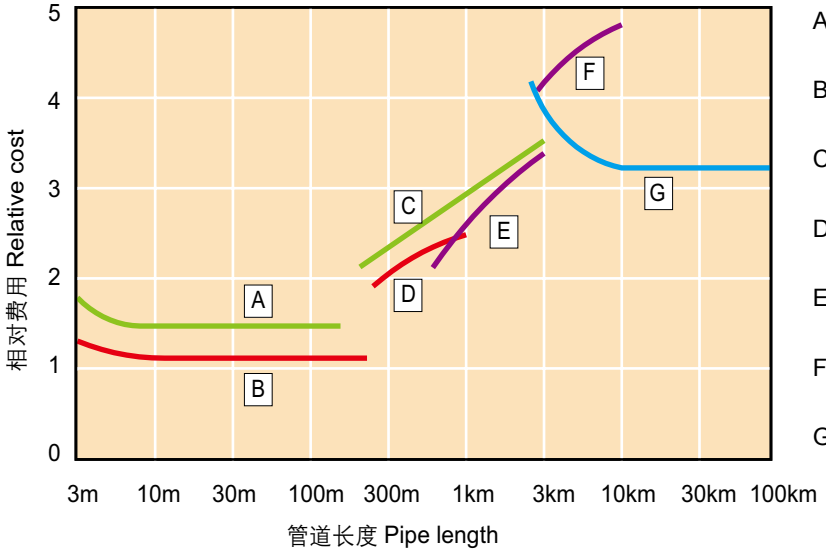
运行温度 Operating Temp.	-50℃～+200℃
供电电压 Power Supply	≤ 5KVAC，50HZ
输出功率 Power Output	(见右图) (see curve)



结构
Construction

1、供热管 Heat producing element	直径为20-60mm、厚度为3-4mm的低碳钢管 Low carbon steel tube with diameter of 20-60mm and wall thickness of 3-4mm
2、通电导体 Current carrying conductor	特殊导体解决了高达5KV的高压，200℃的高温及安装过程中的机械应力。 Special conductor resistive to high voltage(up to 5kV), high temperature(up to 200℃) and mechanical stress at installation
3、防腐保护 Anti-corrosion protection	在加热管外可涂有环氧树脂涂层（根据用户要求） Epoxy coating of a skin heater(as customer request)

集肤效应系统与其他型号加热器的效率对比图
Efficiency of Skin System in Comparison with Heaters of Other Types



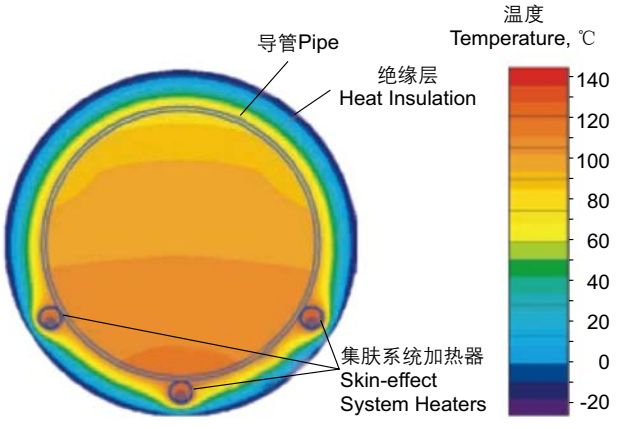
A、自调控伴热系统
Self-regulating
B、并联恒功率伴热系统
Zonal
C、自调控+控制系统
Self-regulating +Supply Network
D、并联恒功率+控制系统
Zonal+Network
E、三芯串联长线
3-conductor Longline
F、单芯串联长线+控制系统
1-conductor Longline+Supply Network
G、集肤系统
Skin-effect System

控制系统

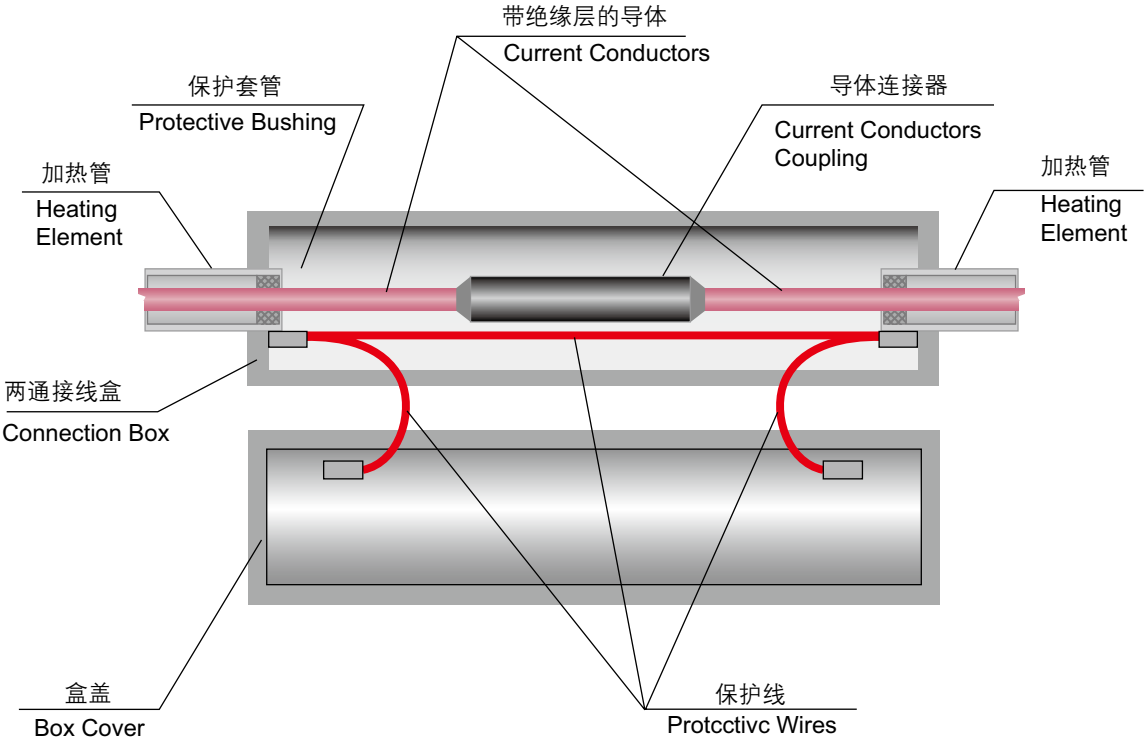
为了提高集肤效应系统的效率，可以配有随着周围环境温度升高而降低加热功率的控制系统。控制系统可以让用户能够可靠地监控系统的工作状态和及时显示突发状况的发生。

Control System

In order to improve its efficiency Skin-system is provided with a control system, which decreases heating power in response to rise of ambient temperature. Control system reliable monitoring of the system status and revealing of emergency conditions.



集肤系统的两通接线盒
Splice Box for Skin-system Heating Elements



集肤系统的电加热截面图
Tube with Skin System Heater Passing Temperature Compensating Movable Pipeline Support