From the 300-year-old iron pipes at the UNESCO World Heritage Site to the concepts of today – a lasting infrastructure for water management

By Harald Roscher and Jürgen Rammelsberg

Fig. 1:
UNESCO World Heritage Site – Bergpark Wilhelmshöhe in Kassel with the Hercules monument and cascades
Source: Museumslandschaft Hessen Kassel

1 Bergpark Wilhelmshöhe in Kassel – a World Heritage Site

On Sunday, 23 June 2013 it was reported in the media that Bergpark Wilhelmshöhe, a mountain park in Kassel, with its Hercules monument and cascades **(Fig. 1)** had been proclaimed a World Heritage Site by the UNESCO jury. This recognition includes the Riesenschloss (an octagonal building constructed in 1701) with the 8 m high statue of Hercules (completed in 1717) and the cascades.

At the request of the Kassel Museum to the board of Frontinus Gesellschaft e.V., H. Roscher examined the iron pipes still in operation in the Octagon and reported:

"The pipes found in the Octagon almost certainly date back to the time when the building came into being. They are socket pipes, approximately 2 m in length, which are around 300 years old" [1].

As we were to learn from the German National Committee of ICOMOS (International Council on Monuments and Sites), which provides expert advice for the World Heritage Committee, the authenticity of the technique was an essential criterion for a positive recommendation.

The present-day measures to restore and preserve this significant architectural monument from the beginning of the 18th century resulted in the Frontinus company being asked for help with an appraisal of the iron pipes. H. Roscher was asked to examine damaged pipes which had been removed and estimate their age, along with the pipes inside the Octagon. Right at the beginning of the building work, in 1704 and 1708, it was agreed that the cascades and the superstructure of the Octagon should be constructed. This raises the question of whether the iron piping systems found in the interior of the Octagon date from this construction period or a later one.

At the same time, questions about the preservation and the renovation and/or renewal of the remaining pipelines still in operation were of interest. The preservation of the old pipes as a historic record played an important role here.

Visits were arranged on 11 March 2010 and 8 April 2010 for the inspection and both excavated pipes and also the pipes located in the Octagon were examined and assessed by H. Roscher **(Figs. 2 and 3)**.

Fig. 4 shows pieces of pipe stored in the garden of the Wilhelmshöhe castle park at the time of the inspection and underneath there is also a sand-cast pipe with an eggshell fracture.

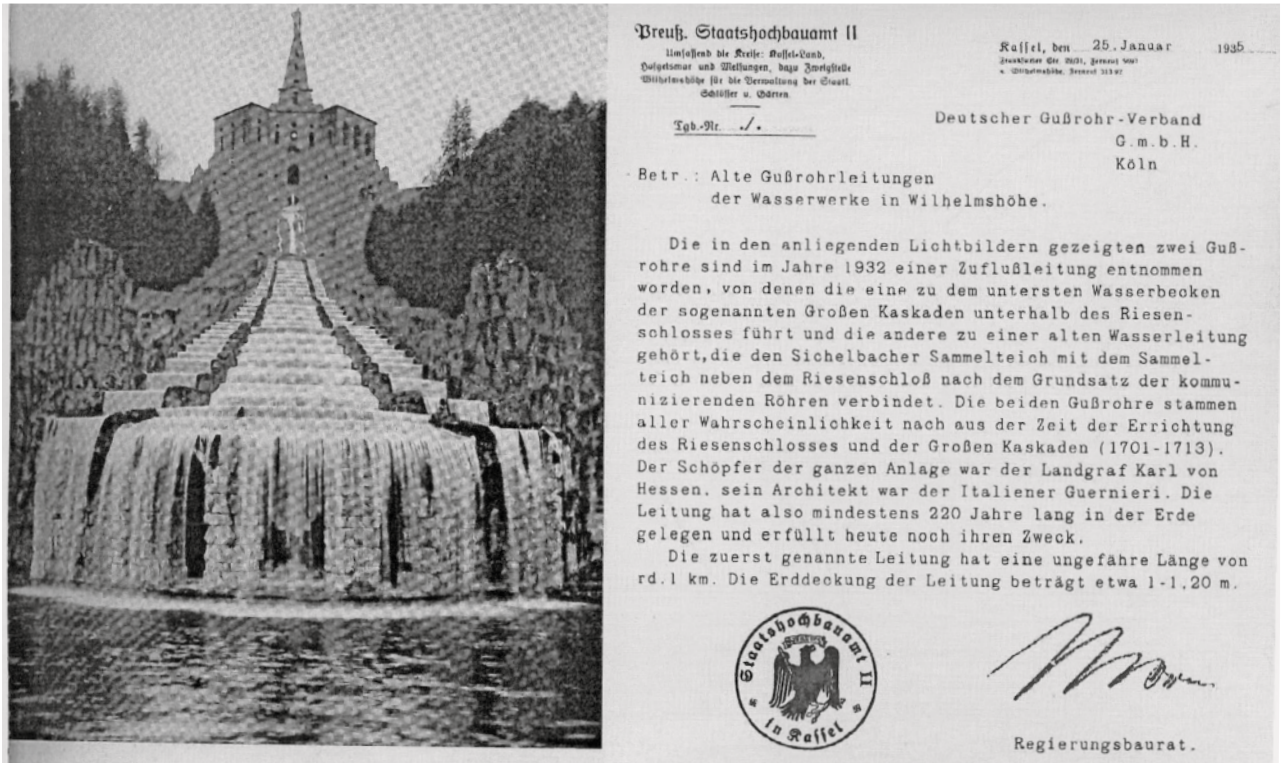
Fig. 2:
The socket joint of an iron pipeline installed in the Octagon
Source: H. Roscher – photographed on 11 March 2010

Fig. 3:
Cast iron pipeline in operation in the Octagon UNESCO World Heritage Site – Bergpark Wilhelmshöhe
Source: H. Roscher – photographed on 8 April 2010

2 Document from the archives of the Association for Iron Pipe Systems helps to determine the age of the iron pipes at Wilhelmshöhe

H. Roscher was able to obtain a copy of the document shown in **Fig. 5** from the archives of the European Association for Ductile Iron Pipe Systems · EADIPS®/Fachgemeinschaft Guss-Rohrsysteme (FGR®) e.V. from which it can be seen that research into "old pipes" was already being conducted by the cast iron pipe industry as early as 1935. In a letter from the Prussian state building authority **(Fig. 5)**, the age of the cast iron pipes is given as more than 200 years [2].

Fig. 4:
Iron pipes stored in the garden of Wilhelmshöhe castle park
Source: Museumslandschaft Hessen Kassel



Preuß. Staatshochbauamt II

Kassel, den 25. Januar 1935

Deutscher Gußrohr-Verband
G.m.b.H.
Köln

Betr.: Alte Gußrohrleitungen
der Wasserwerke in Wilhelmshöhe.

Die in den anliegenden Lichtbildern gezeigten zwei Gußrohre sind im Jahre 1932 einer Zuflußleitung entnommen worden, von denen die eine zu dem untersten Wasserbecken der sogenannten Großen Kaskaden unterhalb des Riesenschlosses führt und die andere zu einer alten Wasserleitung gehört, die den Sichelbacher Sammelteich mit dem Sammelteich neben dem Riesenschloß nach dem Grundsatz der kommunizierenden Röhren verbindet. Die beiden Gußrohre stammen aller Wahrscheinlichkeit nach aus der Zeit der Errichtung des Riesenschlosses und der Großen Kaskaden (1701-1713). Der Schöpfer der ganzen Anlage war der Landgraf Karl von Hessen, sein Architekt war der Italiener Guernieri. Die Leitung hat also mindestens 220 Jahre lang in der Erde gelegen und erfüllt heute noch ihren Zweck.

Die zuerst genannte Leitung hat eine ungefähre Länge von rd.1 km. Die Erddeckung der Leitung beträgt etwa 1-1,20 m.

Staatshochbauamt II in Kassel

Regierungsbaurat.

Fig. 5:
Letter from the Prussian state building authority – Old cast iron pipelines of the water works in Wilhelmshöhe
Source: Einst und Jetzt, Deutscher Gußrohr-Verband G.M.B.H., Cologne

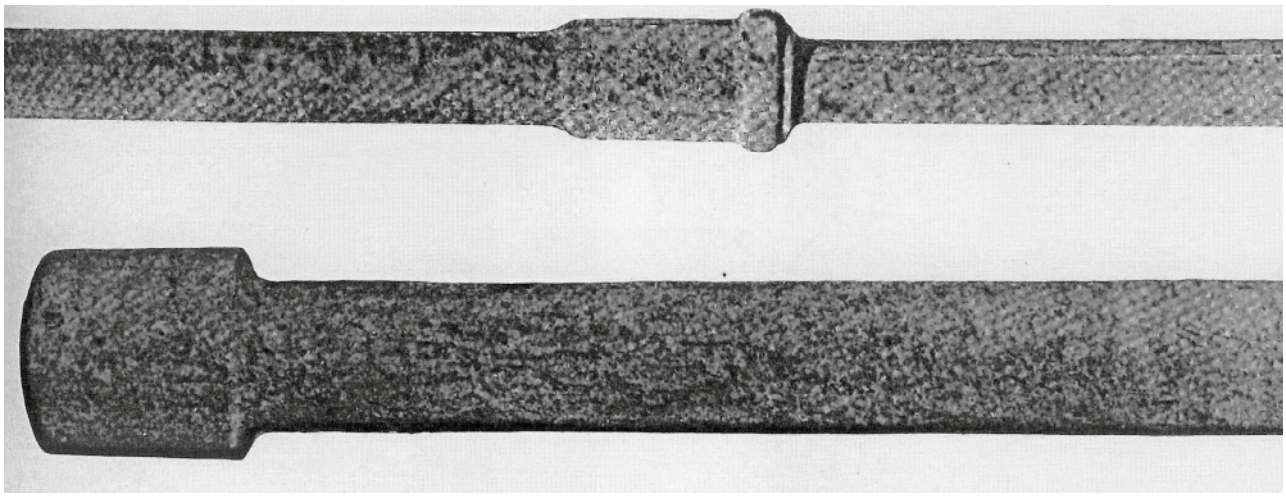


Fig. 6:
Exposed iron pipes at the Wilhelmshöhe castle from 1713
Source: Einst und Jetzt, Deutscher Gußrohr-Verband G.M.B.H., Cologne

This letter is a particularly valuable document as it is useful for determining the age of the pipes still in existence today. **Fig. 6** shows cast iron pipes from Wilhelmshöhe [2].

3 On the further historical development of the iron pipe

The oldest cast iron pipeline known to us in German soil is the water pipe from Dillenburg Castle to the river Dill; this came into being in around 1455. **Fig. 7** shows a pipe from the line which was in use until the destruction of the castle in the year 1760.

The first larger, municipal water pipe networks were constructed by the cities of London and Vienna in around 1800. In Germany, the first municipal water pipelines arrived in Hamburg in around 1858 and in Berlin and Darmstadt in 1850 to 1865.

A brief summary on developments in the manufacture and application of iron pipes for water supply is given in Chapter 1 of the "Ductile Iron pipe systems" E-book, which can be found on the website www.eadips.org by clicking on "Publications" [3].

The most notable milestones are:

1455	one of the oldest iron pipelines was constructed; this was the water supply line for Dillenburg Castle.
1562	a water pipeline was laid in Langensalza to supply the Jacobi and Rathaus fountains.
1661	the water pipeline for the castle in Braunfels was constructed. The iron pipes were in operation until 1875 and were dug up in the course of sewer laying work in 1932.
1664–1668	the pipeline was laid in the grounds of the Palace of Versailles to feed the water fountains there **(Fig. 8)**.
1710–1717	the construction of the cascades in the Kassel-Wilhelmshöhe castle park with the Hercules monument. Cast iron pipeline to supply the water features with water. Since June 2013 the Hercules monument along with the cascades has been a World Heritage Site.
1720	cast iron pipe for the supply of water for the Zwinger Palace in Dresden (Weißeritz pipe, **Fig. 9**).

Fig. 7:
Cast iron pipe, as was installed in Dillenburg Castle until 1760
Source: "Ductile iron pipe systems" E-book, issue 10.2013, Figure 1.1

Fig. 8:
Cast iron pipe from the Palace ground of Versailles
Source: H. Roscher

Fig. 9:
Excavated cast iron pipe from the so-called Weißeritz pipe
Source: Foto Kästner, Dresden

For the municipal drinking water supply networks constructed since the middle of the 19th century, grey cast iron was available as the material almost without exception. Later on, steel came along as an additional material. The statistics of the German gas and water management association show that, until the nineteen fifties, the proportion of cast iron pipes in the existing water supply network was 85 % in the Federal Republic of Germany.

The main area of use of cast iron pipes – and since around 1960 of pipes and fittings in ductile cast iron and valves in spheroidal graphite cast iron – lies in the area of community water supply.

The major steps in the further development of cast iron piping have to do with corrosion protection and assembly techniques, culminating in the perfection of restrained joints enabling the pipes to be laid using the trenchless technique. These development stages are described in [4] and they are identified in terms of generations.

As from 1968, 1st generation pipes and fittings in ductile cast iron are zinc-coated with a protective finishing layer on the outside and lined with cement mortar on the inside. From 1979 onwards, the 2nd generation have an external polyethylene (PE) or polyurethane (PUR) coating or a fibre-reinforced cement mortar coating. These coatings are suitable for soils of every type and have resulted in a further decrease of the damage rate, which was already low to begin with [5].

4 Sustainability in the water management infrastructure – a modern-day challenge

Current demands placed on all those involved in economic processes are characterised by the term "sustainability". In its broadest sense, this is understood to be the conservation of all resources for present and future generations.

Specifically this can refer to the economic aspect, in that the cost of an investment is compared with the running costs throughout its entire useful life, which include the costs of installation, operation, maintenance and also decommissioning.

Because of their long working life and their low damage rates, ductile iron pipes and fittings of the second generation are one of the economically superior pipe systems for the water management industry. This is underlined by their economically efficient connection and assembly technique, particularly in areas where access is difficult or where the trenchless laying technique is used.

As regards the ecological aspect, it is the material properties which take the foreground. Ductile iron pipe systems are diffusion-tight, which is essential for the transport of drinking water where the soil is contaminated for example. By contrast, when waste water and sewage are being carried it is the soil and groundwater which need to be protected against pollutants. Linings have been used in piping systems for decades to ensure the absolute hygienic safety of drinking water.

A particularly important factor when considering things from an ecological point of view is the fact that ductile cast iron is obtained almost exclusively from the recycling of iron and steel scrap and that ductile iron pipes, fittings and valves can be completely recycled again at the end of their technical working life without damage to their material properties [6].

In addition to the economic and ecological advantages, there is a third aspect which involves the technical superiority of ductile iron pipe systems: their performance level offers the highest degree of security in all areas of water transport because the components are mechanically resistant to the highest pressures, longitudinal bending and surface loads. This in turn can result in considerable savings once the pipes are installed. Such a combination of properties has led to new and special applications such as snow-making systems and hydroelectric power stations in mountainous regions, and also to fire extinguishing lines in road and rail tunnels and industrial plants.

As a material with excellent technical performance capabilities, ductile cast iron offers security and lasting economic advantages for water management. Combined with its ecological properties and its extraordinarily long working life, this makes ductile cast iron the only material in the water industry which demonstrably offers true sustainability.

5 Conclusion

What was required of the pipes in the 300-year-old World Heritage Site in Kassel-Wilhelmshöhe at the time was that they should withstand the type of internal pressures which were needed to operate the water features. There were probably no other requirements. Even at the time the pipes were considered "luxurious", but for the pressures desired only cast iron pipes would do [7].

Developments in the period from 1710 to the present day have been characterised by improvements in the material, in the production process, in corrosion protection and in joint techniques, together with progressive installation techniques. All in all it amounts to a successful effort at working in a way which protects resources for current and future generations.

6 Bibliography

[1] Roscher, H.:
Gutachten zu Gussrohren aus dem Bergpark Kassel-Wilhelmshohe
2010-04

[2] Gusseiserne Rohre „Einst – Jetzt"
Deutscher Gussrohr-Verband G.m.b.H., Cologne

[3] EADIPS®/FGR® website,
www.eadips.org, Publications,
"Ductile iron pipe systems" E-book,
issue 10.2013, chapter 1,
p. 1/3

[4] Roscher, H.:
Rehabilitation von Wasserversorgungsnetzen,
2nd edition, Berlin 2009,
p. 77

[5] Sorge, H.-C.:
Zustandsbewertung von Gussrohrleitungen anhand materialtechnischer Kenndaten
GUSSROHR-TECHNIK 42 (2008),
p. 62

[6] CEN/TR 16470
Environmental aspects of ductile iron pipe systems for water and sewerage applications
[Umweltrelevante Aspekte von Rohrleitungssystemen aus duktilem Gusseisen für die Wasserversorgung und die Abwasserentsorgung]
2013

[7] Leupold, J.:
Schauplatz der Wasserbaukunst;
Leipzig 1724,
p. 78

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