National
Trust

The Needles Old Battery

Installation of modern heating technology

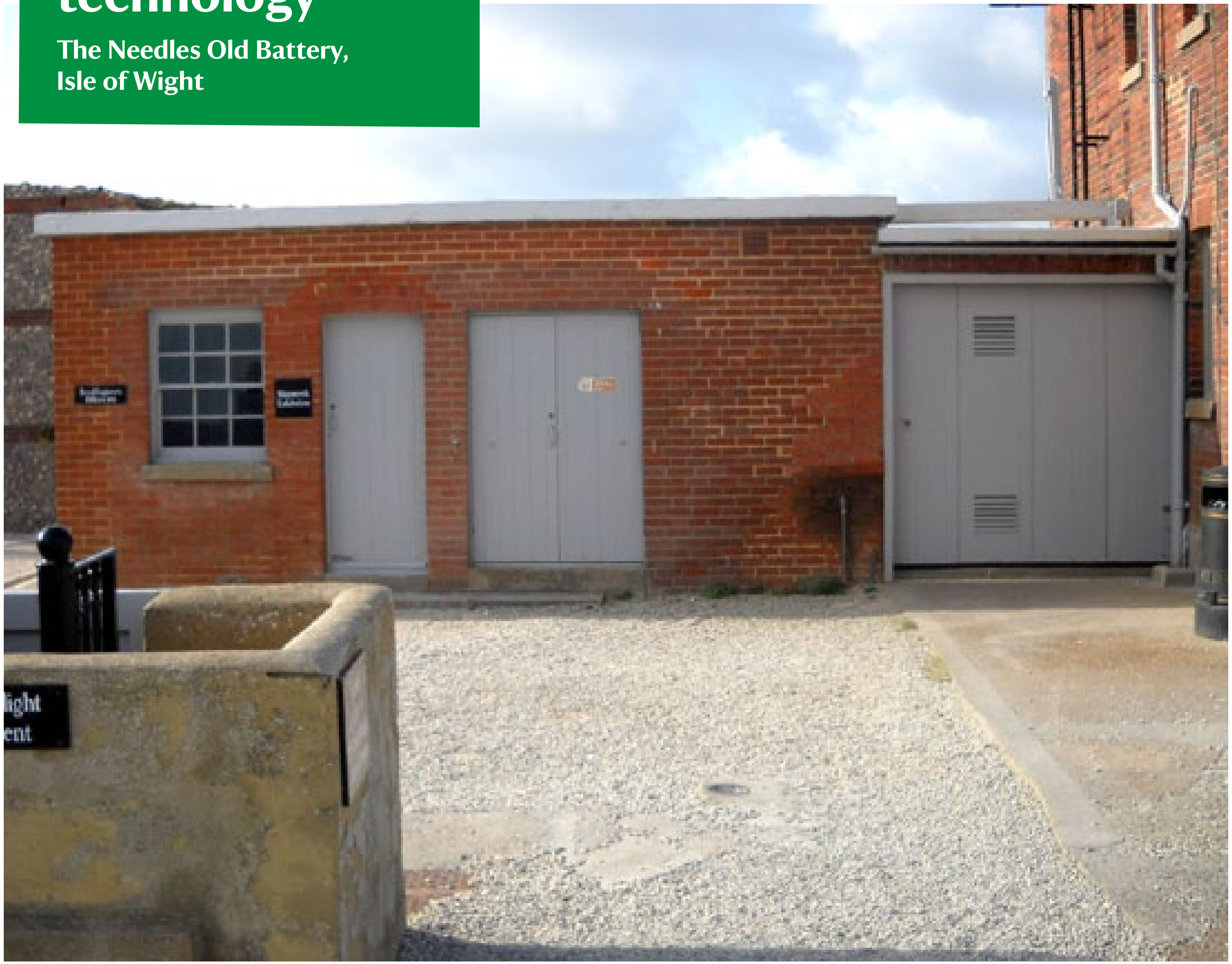
March 2010

Building Design Guide

- air source heat pump
- installation of insulation and secondary glazing
- engagement with visitors

Installation of modern heating technology

The Needles Old Battery, Isle of Wight



Background

The Needles Old Battery is positioned high up on the exposed headland of the far west coast of the Isle of Wight. It is the site of a twentieth century brick cavity-walled building currently used as a tearoom for visitors, office and storage space for staff, and additional exhibition and viewing spaces looking out over the sea. The building had single glazed metal casement windows with no roof insulation. Some rooms were considered almost unusable for staff during cold weather, even with the heating on.

Heating was supplied by an oil-fired boiler; however the National Trust fuel hierarchy considers oil the least acceptable in favour of any other fuel type. An internal Compliance Audit highlighted the oil system as a risk to the site given the local area's designation as an Area of Outstanding Natural Beauty (AONB), Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC), and funding was offered for its removal.

The 'Needles Sustainable Energy Feasibility Study' recommended replacement of the oil boiler with an air source heat pump (ASHP) as a means of reducing CO_2 emissions.

In February 2009, the oil boiler finally broke down and the parts needed for repairs were unavailable, thus intensifying the urgent need for the project.

Left **The Plant room where the oil storage tank was originally housed, showing oil staining and evidence of many alterations to the original brickwork and openings prior to the project beginning**

Project brief

The project aimed to:

- Remove the oil system entirely from the site to eliminate the risk of ground contamination

- Simplify the heating system and consolidate all the heating plant into one room

- Install a sustainable alternative for space heating and hot water

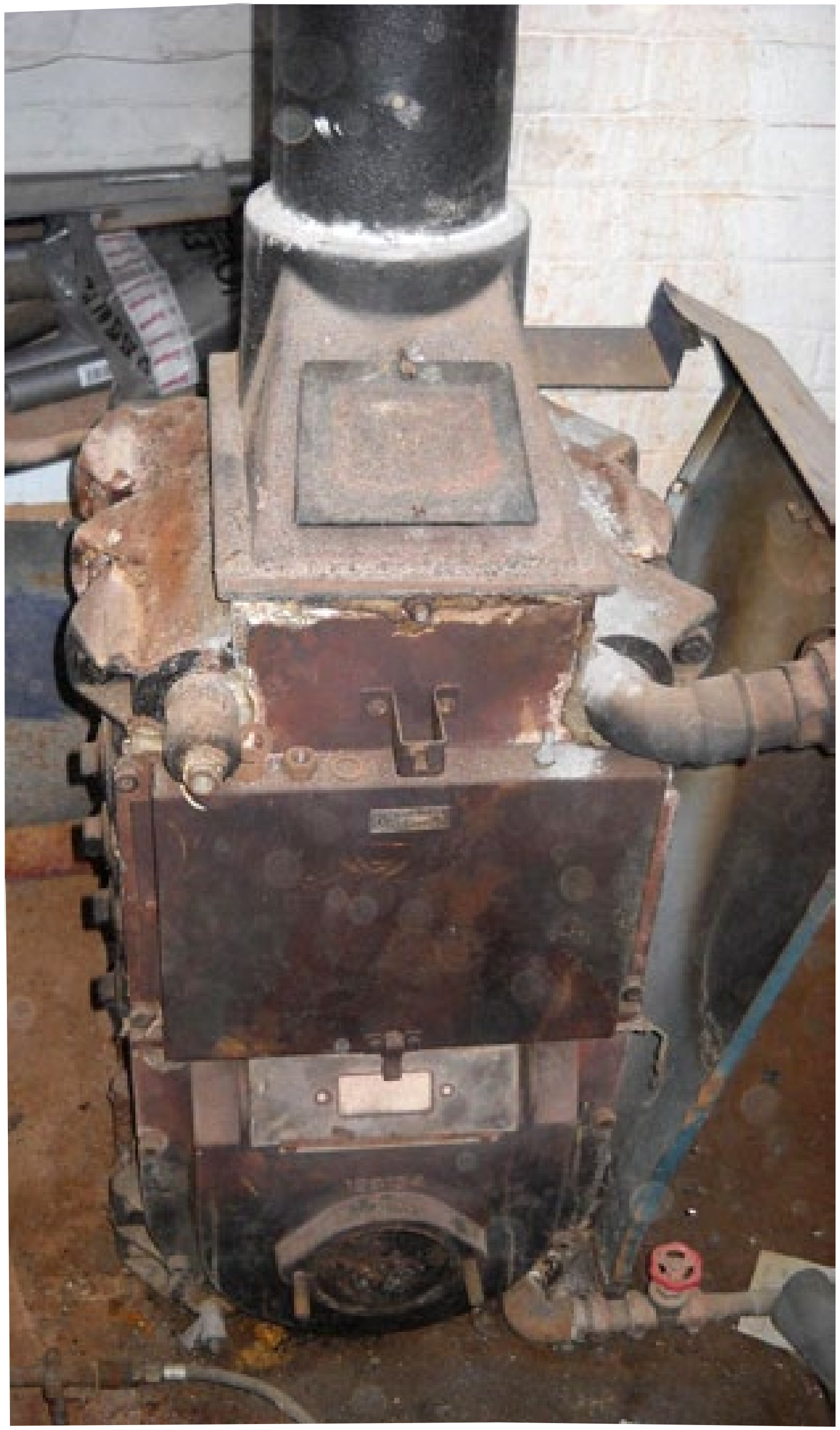
- Improve the thermal performance of the building to reduce heat loss, and therefore energy consumption, CO_2 emissions and heating costs

- Improve the comfort levels for staff and visitors, making the building more useable throughout the year

- Maintain the aesthetic feel of the exterior and interior of the building, and minimise damage to the historic fabric during the works, in consideration of its listed status and Scheduled Ancient Monument designation

- Minimise disruption to tearoom sales and visitor access by committing to a short contract period

- Engage visitors with the project



Key factors

- Removal of the oil-fired boiler and pipe system
- Installation of a sustainable heating system
- Installation of roof insulation, secondary glazing and local thermostatic controls
- Additional new radiators to improve comfort levels
- Minimise damage to historic fabric and aesthetic
- Interpretation boards for visitors
- Short contract period

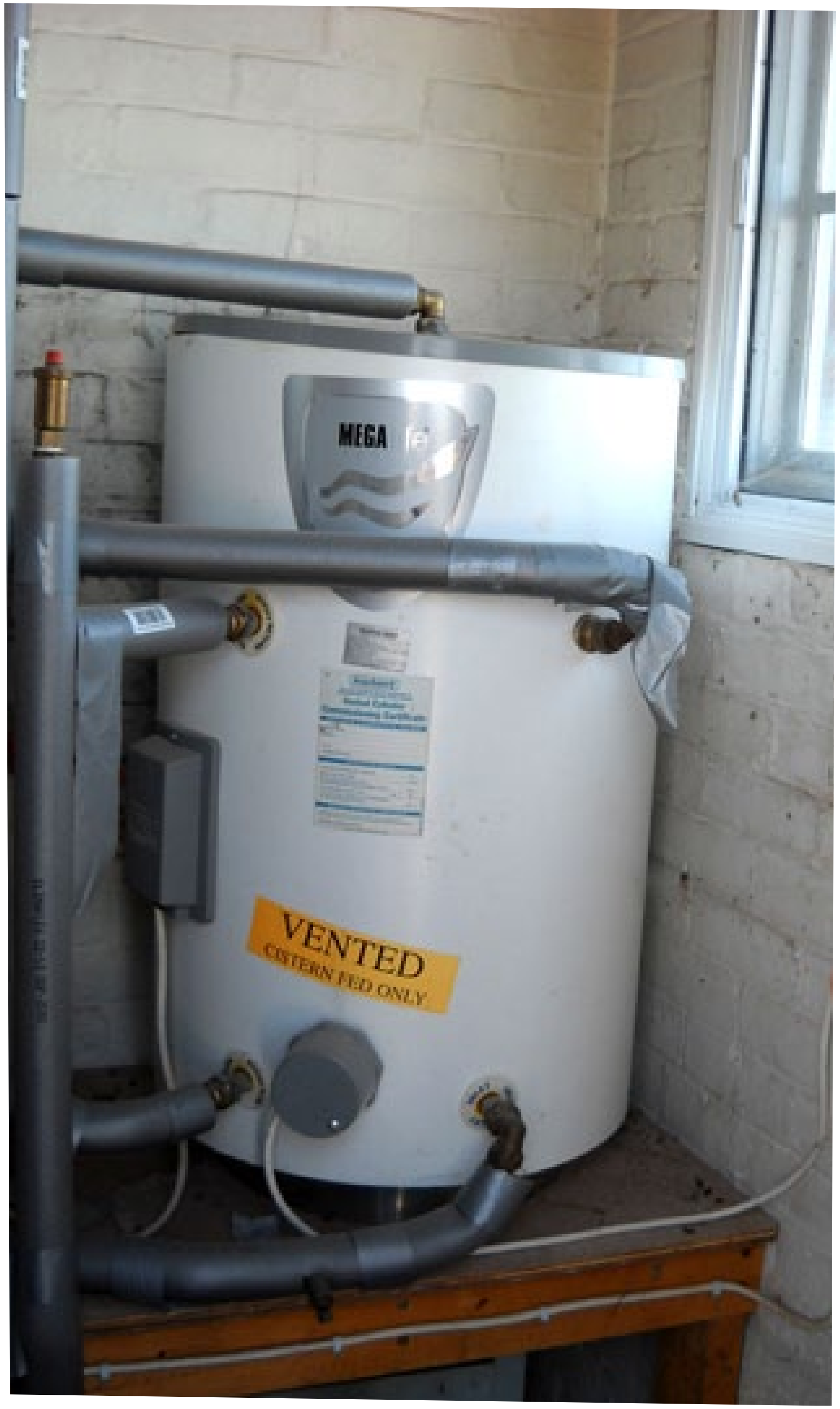
Consultees

- Conservation Officer
- English Heritage
- Environmental Practices Advisor (funding support)
- Planning Authority
- Property Manager
- Regional Building Team (funding support)
- Fort Manager/Custodian
- Trinity House (owners of the Needles Lighthouse)

Left **The original oil-fired boiler**

Designations

- Area of Outstanding Natural Beauty (AONB)
- Grade II listed building
- Heritage Coastline
- Scheduled Ancient Monument (SAM)
- Site of Special Scientific Interest (SSSI)
- Special Area of Conservation (SAC)



Site issues

- Access to the site is via a wooden bridge and tunnel, this imposed both a weight limit and size restriction on all construction vehicles.

- The site is closed to the public during January and then open at weekends during February and seven days a week during March to November. A restricted contract period carefully timing works to reduce disruptions to public access and sales in the tearoom was necessary.

- Separate planning consents were required for the works to comply with both the Grade II listing and Scheduled Ancient Monument status.

- Exposure to the weather at the site, and particularly wind-blown chalk dust from the surrounding landscape meant the risk of damage to externally mounted equipment would need to be considered.

- The buildings have flat concrete roofs limiting the options available for the installation of insulation.

Top left **The original oil tank**

Bottom left **The existing hot water tank**

Design approach

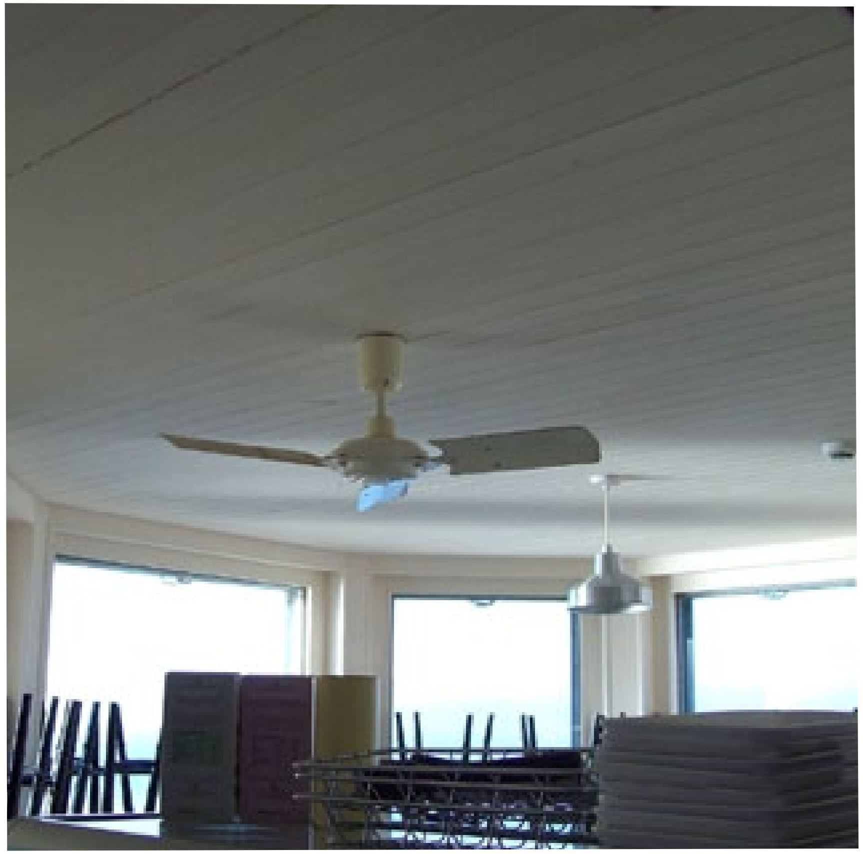
The existing system had the oil tank stored in the Plant room, the oil boiler in a separate room in the main building with oil pipes running around the Parade Ground to the Guard Room. Specialist contractors (OFTEC) were required to safely remove the existing oil boiler, heating pipes, and external oil pipes which were buried under the yard flagstones in close proximity to the drainage system and the archaeological remains of the original structures.

The building had a mixture of original cast iron radiators and newer modern additions in various styles. The existing cast iron radiators were retained where possible, but one undersized radiator was replaced with a new cast iron column radiator. It was decided to install modern twin panel 'Booster' radiators in a previously unheated area and to replace the two existing modern radiators in the main tearoom. The new system followed the old layout as much as possible to minimise the impact on the building fabric. The new pipes and radiators were chosen to complement but not replicate the existing thereby maintaining the aesthetic; this was helped by painting the radiators to match the existing tearoom decoration. All of the radiators are fitted with thermostatic valves.

The main electrical capacity of the site was carefully considered to allow for the extra load contributed by the ASHP.

Top right **Original Matchboard ceilings in the tearoom**

Bottom right **Existing cast iron radiator**



The decision was made to mount the ASHP internally with the accompanying controls and water storage tanks, thus limiting possible damage from exposure to weather and wind-blown chalk dust to the external louvres. This also minimised the aesthetic impact on the site externally. However, internal positioning of the unit reduced the available choice of ASHP system manufacturers.

Internal mounting of the system required some structural works to install large air ducts that would not be required for an external system, but the benefits of less exposure and wear over time should mitigate this additional cost.

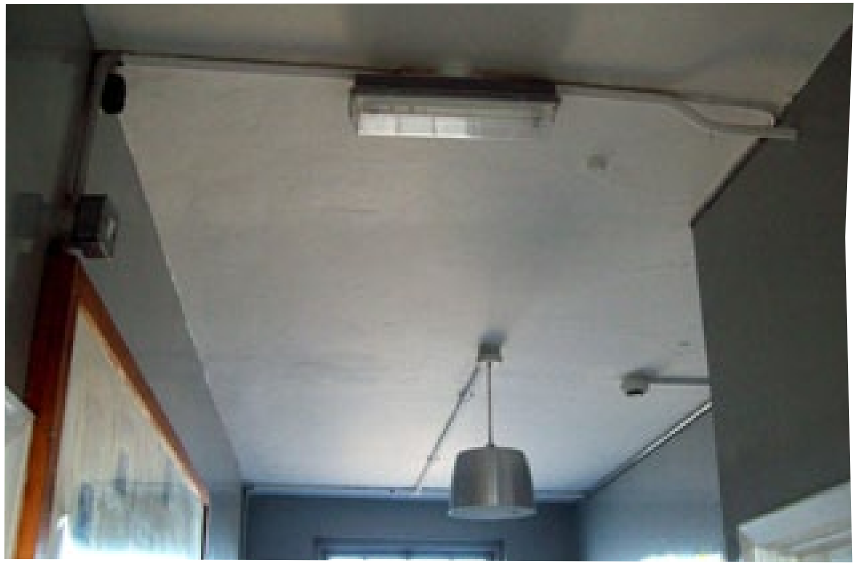
The roof insulation had to be installed internally due to the concrete flat roof; however alterations to the ceiling heights were also restricted due to the position of the windows. The original tongue and groove Matchboard ceiling in the main tearoom was carefully removed and reinstated with insulation restricted to the depth of the ceiling joists. The landing, kitchen, and servery had original smooth rendered ceilings with surface mounted electrics, so new false ceilings were added just above full window height to allow the maximum possible insulation depth. A new tongue and groove Matchboard finish was chosen in keeping with the main tearoom fixed to new softwood ceiling joists, and the existing electrical fittings were wired to the new lower level.

Design approach

Engagement
Interpretation boards were provided to explain the ASHP; however visitors expressed further interest in seeing inside the Plant room. The external doors were accordingly adapted and a glass sliding door positioned to allow safe public viewing.

Environmental
The idea was to eliminate the risk of contamination caused by oil and to reduce reliance on fossil fuels by installing a modern sustainable system. In order to fully exploit the benefits of the new heating system it was deemed appropriate to improve the thermal performance of the building by adding in roof insulation and secondary glazing. Photovoltaic cells will be installed on the flat roof to help generate electricity requirements.

Health and Safety
The power supply to the Needles Old Battery also supplies the local Needles Lighthouse which runs 24 hours a day. The owners needed to be informed prior to a power shut down to ensure their backup system was working, thus preventing disruption to the lighthouse service.



Top right **The existing smooth rendered ceiling, showing the surface mounted electrics and the height of windows which required the installation of a false ceiling for insulation**

Bottom right **The Plant room's concrete flat roof, the proposed site for Photovoltaic panels**

Project team

The project team comprised people and companies providing internal and external expertise including:

- Project manager
- Building surveyor
- Environmental practices advisor

Main contractors
Paul Taylor, Clarke's Mechanical

Electrical contractor
Sexton's (Isle of Wight) Ltd.

Sub-contractors

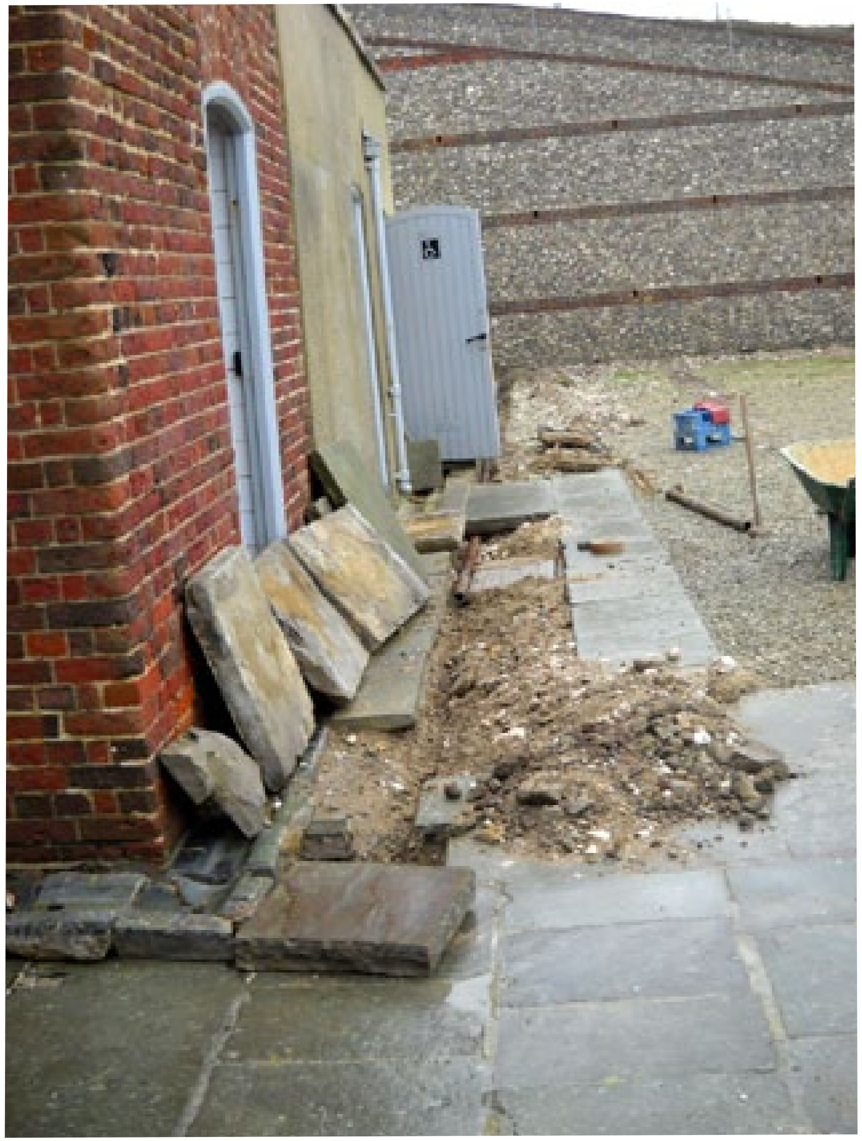
Carpentry/Decoration
Bucketts (Isle of Wight) Ltd.

Construction

Oil pipes
The external oil pipe system ran underground skirting the perimeter of the Parade Ground. The oil pipe removals were carried out over a couple of weeks during December 2009 and timed to enable weekend opening to visitors. The pipes had a static pressure test to ensure that they were sound before being flushed through with water prior to removal; this prevented any contamination of the ground. One pipe length ran under flagstones; one of these was too heavy to move without undue cost so the specialist removed it hydraulically. All other pipes were dug out by hand to prevent damage to the nearby footing remains of original structures. The flagstones were re-laid in their original positions.

Air source heat pump
The ASHP was installed and mounted internally to avoid damage from weather exposure and windblown chalk dust from the surrounding site. The pump absorbs heat from the outside air and so had to be fitted with both an intake and discharge louvre to the outside. This involved making two holes in the Plant room external walls positioned where plenty of fresh air would circulate around the inlet louvre. The louvres were positioned on opposite walls creating a cross flow through the building from back to front. The intake louvre was positioned on the south facing wall to exploit maximum heat gains.

The pump extracts heat from the air in the same way that a fridge extracts heat from its interior. It can continue to extract heat even when the outside temperature is as low as -15°C. Heat from the air is absorbed into a fluid which is pumped through a heat exchanger in the heat pump. Low grade heat is then extracted by the refrigeration system and, after passing through the heat pump compressor, is concentrated at a higher temperature capable of heating water stored in tanks for space heating and hot water.



Above **Oil pipe ready to be removed from under flagstones by the pully system**

Unlike the oil boiler the ASHP delivers the heat at lower temperatures. This means that the radiators are not expected to feel as hot to the touch as they would from an oil boiler (which in a public building has health and safety advantages); however this does mean that the ASHP system works more effectively with underfloor heating or larger radiators which can give out heat at lower temperatures over longer periods of time. Where standard radiators are used it is generally recommended that they are approximately 50% bigger than normal however, here twin panel boosted radiators were added into the system alongside the original cast iron radiators. The boost enables them to operate at low temperature without needing to be oversized.

The system is operating 24 hours a day due to the seven day opening for visitors. Closed periods generally coincide with cold periods of weather so the system is left on to protect against frost damage, and an automatic process heats the hot water cylinder to a high temperature for an hour every night to safeguard against Legionella.

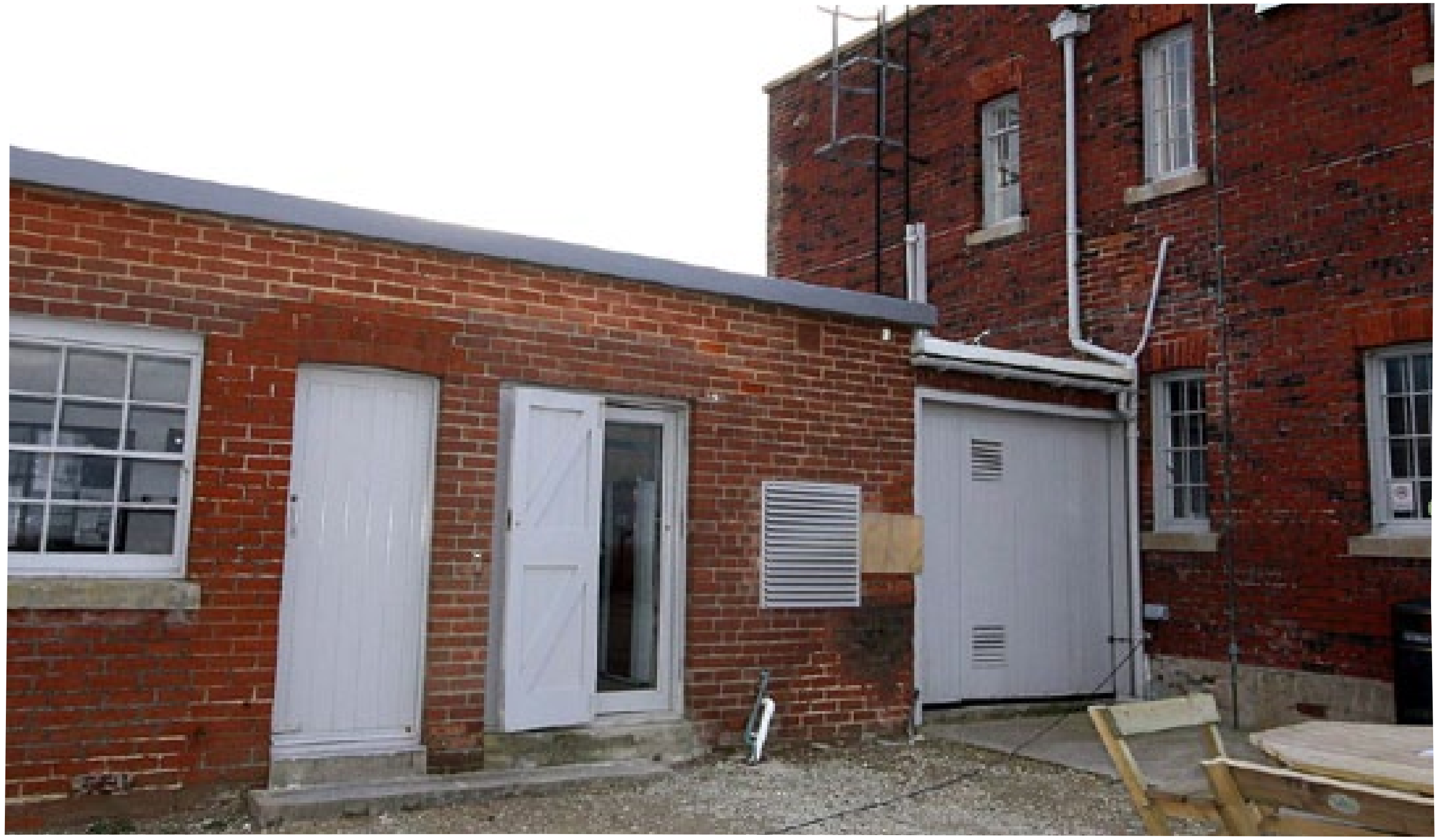
The ASHP uses electricity to drive the pump and so is not entirely without environmental impact but the heat extracted from the air is constantly renewed naturally.

The ASHP is expected to require very little maintenance. As there will no longer be any fuel deliveries required to the site, a constant uninterrupted supply of heat is available.

The new external louvres were finished off with paint in 'Goosewing Grey' to match existing site colours.

Existing radiators were flushed clean before reconnecting to the system. Carbon steel pipe work replaced the heating pipes to radiators and hot water cylinders.

Construction



Insulation
A single layer of 100mm Celotex dense foam insulation was used between the ceiling joists with a layer of Triso Super 10 multifoil insulation crossing under the joists as a vapour barrier to enable the lowest possible u-value in a restricted space. The electrics had to be adapted to compensate for the new false ceiling heights with the wiring set above the insulation to avoid wires from overheating.

Conservation building work

- Minimising the effect of intervention works to the building fabric and aesthetic by following existing pipe runs.

- Carefully selecting products and materials to complement the original.

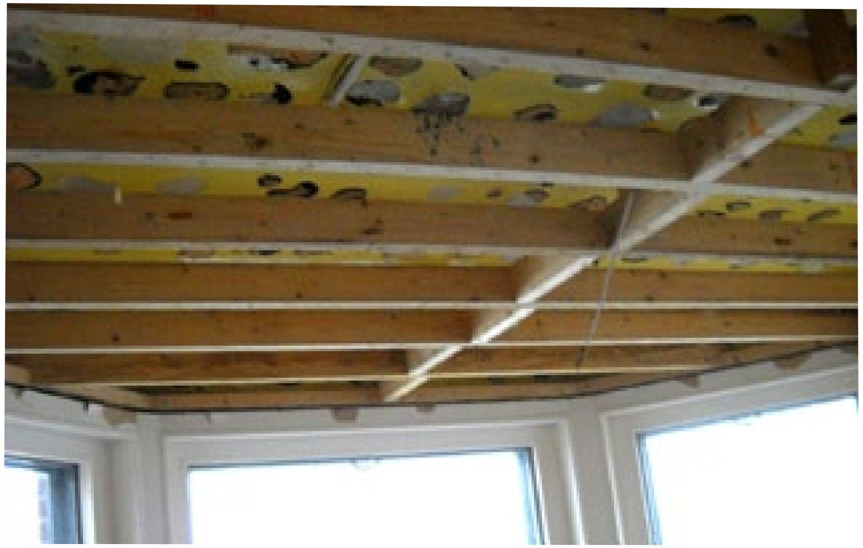
Associated repairs

- Internal decorations to the tearoom were undertaken after the works were completed.

- Repairs were made to the redundant oil boiler room in the main building, to make it into a store room. The ASHP and associated plant have taken up valuable storage space elsewhere so this was considered a suitable solution. Repairs were made to the roof and a new suspended floor was installed.

Top right **The finished exterior of the Plant room showing the new ASHP discharge louvre and sliding glass door installed for public viewing**

Bottom right **Exposed rafters after Matchboard ceiling removed**



Future plans

The plan is to install photovoltaics on the flat roof of the Plant room which will contribute to the building's overall electricity usage. Suitable space for the photovoltaics is restricted due to the sensitive nature of the site thus they will only be able to produce a small percentage of the ASHP's requirements – 2.1kW in the best light, as opposed to the 16kW ASHP requirement. They are to be viewed as a demonstrable technology in a popular visitor spot designed to engage with visitors.

Products and services

Air Source Heat Pump: Dimplex LI 16 TE
Dimplex
www.dimplex.co.uk

Supplied and commissioned by
Clarke's Mechanical
www.clarkesmechanical.com

Mhs Clasico cast iron column radiator
MHS Radiators
www.mhsradiators.com

Booster Radiators: Jaga Strata DBE Radiators
Jaga Heating Products UK Ltd.
www.jaga.co.uk

Solaglas
Solaglas Ltd.
www.solaglas.sggs.com

Celotex 100mm dense foam
Celotex Ltd.
www.celotex.co.uk

Triso-Super 10 multifoil insulation
Actis Insulation Ltd.
www.insulation-actis.com

Above **ASHP installation in progress with inlet opening created in cavity wall**

Left **New ASHP controls**

Funding

- 69% of the project was funded by external grants (86% NPower, 14% AONB) and 31% was funded by National Trust.

Procurement

- There was a requirement to consider NPower approved framework suppliers – ideally those local to the South Coast. Dimplex were selected following a competitive process. They satisfied all these requirements and had an approved contractor on the island for installation works. Dimplex also had already installed an identical system in an island property which allowed the team to view a working demonstration of the system in situ.

- The supplier of the ASHP was a nominated sub-contractor for NPower.

- OFTEC oil specialists were used to remove the oil system.

- The project was split into two parts using separate contractors for each, with an agreed fixed price specification and completion date. The success of this arrangement was due to close and regular contact with all concerned and a commitment to meeting specified deadlines.

Project duration

- Completion of tender documents: March 2009
- Tenders invited: April 2009
- Tenders received: June 2009
- Contractors selected: October – November 2009
- Commenced on site:
  December 2009 (Oil removal)
  4 January 2010 (ASHP)
- Project completion: 26 February 2010

Post project review

■ The project was completed within the short contract period with minimal disruption to visitor access and tearoom sales. The objectives were met fully in terms of the provision of space heating and hot water from a sustainable source. The team are now looking forward to the next phase of the project with the addition of photovoltaic cells for onsite electricity production.

■ The building is consistently warm and comfortable throughout and the system is simple to operate with all the plant housed in one room.

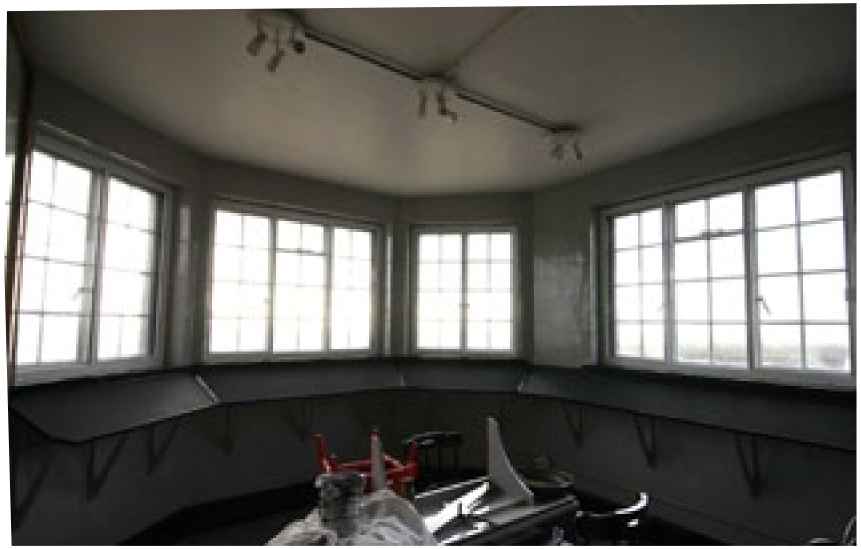
■ The oil system was safely removed without contamination to the site and with minimal damage or disruption.

■ All other works were achieved without any detrimental effect on the site's aesthetic and historic interest.

Best practices

■ Regular site meetings with contractors and inclusion of on-site Trust staff enabled both control of the works and site requirements to be a high priority for everyone. This became particularly relevant when heavy snowfall prevented access to the site for a week during the very short contract period.

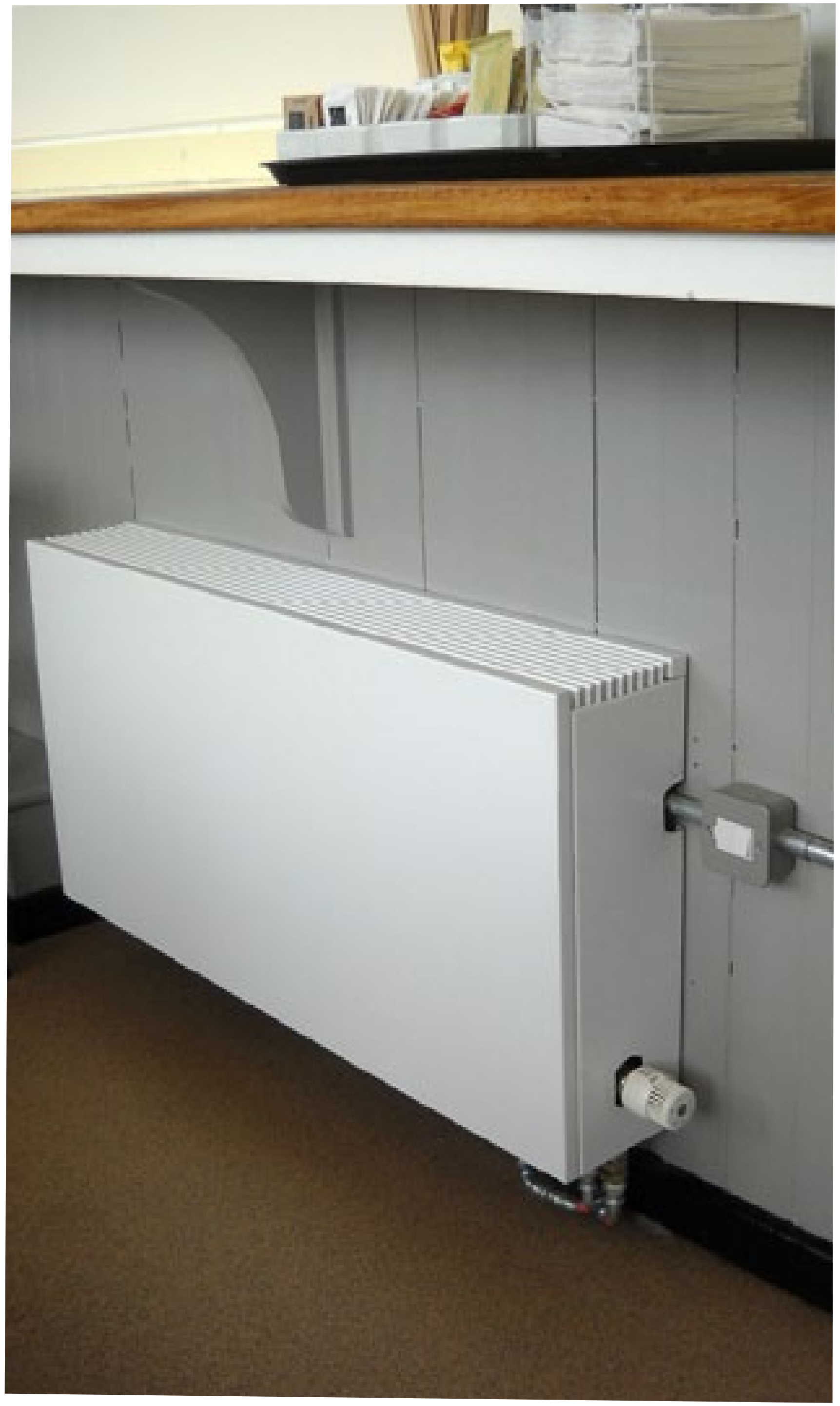
■ Despite the building being Grade II listed and a Scheduled Ancient Monument, the project has proved that it is possible to successfully install a modern sustainable heating system. The choice to mount the ASHP internally and the new installation of pipe work, radiators and ceiling alterations has not affected the aesthetic feel of the building due to careful selection of materials and products.



Above **Plant room interior with the oil tank removed, new hot water storage tanks, ASHP and controls**

Left **Panoramic windows with secondary glazing**

Post project review



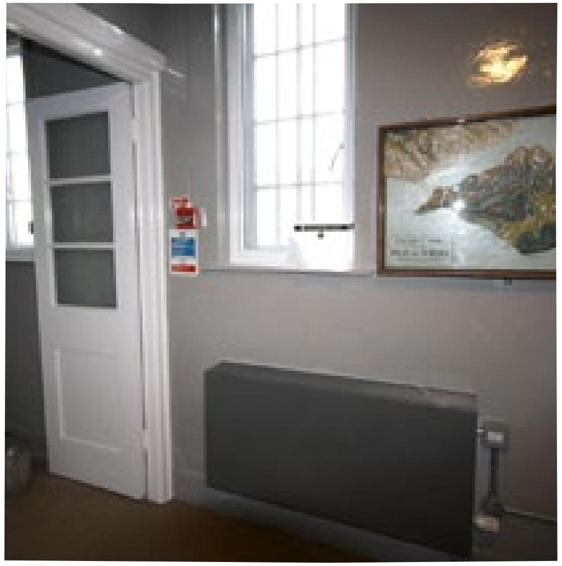
Best practices continued

■ Choosing to improve the thermal performance of the building as well as renewing the heating system has proved very successful. The extra booster function on the new 'booster radiators' has so far not been required despite severely cold weather thus proving that the insulation and secondary glazing is working well to retain heat over night.

■ Considering the electrical capacity of the site prior to installation has proved helpful, avoiding any issues with the new system.

■ The contractors remained on site to conduct other works post project. This has allowed fine tuning adjustments to be made to the ASHP controls, therefore tailoring the system to the user's specific needs. The system has been made more efficient by reducing hot water temperatures and fuel consumption, and staff have had time to familiarise themselves with the controls so that they can make the adjustments themselves in the future.

■ The project was successful in engaging visitors with the new ASHP, so much so that additional measures were taken to allow safe viewing of the ASHP inside the Plant room itself.



Lessons learnt

■ It has not been easy to monitor the performance of the ASHP in terms of measuring actual heat output in relation to the electrical input. A solution has been proposed and is to be tested shortly.

Left **The new Boosted radiator requires an electrical supply to power the booster fan**

Above **Secondary glazing in the hallway with the Boosted radiator painted in Goosewing Grey**

Further information

The Needles Old Battery,
West High Down, Alum Bay, Isle of Wight PO39 0JH

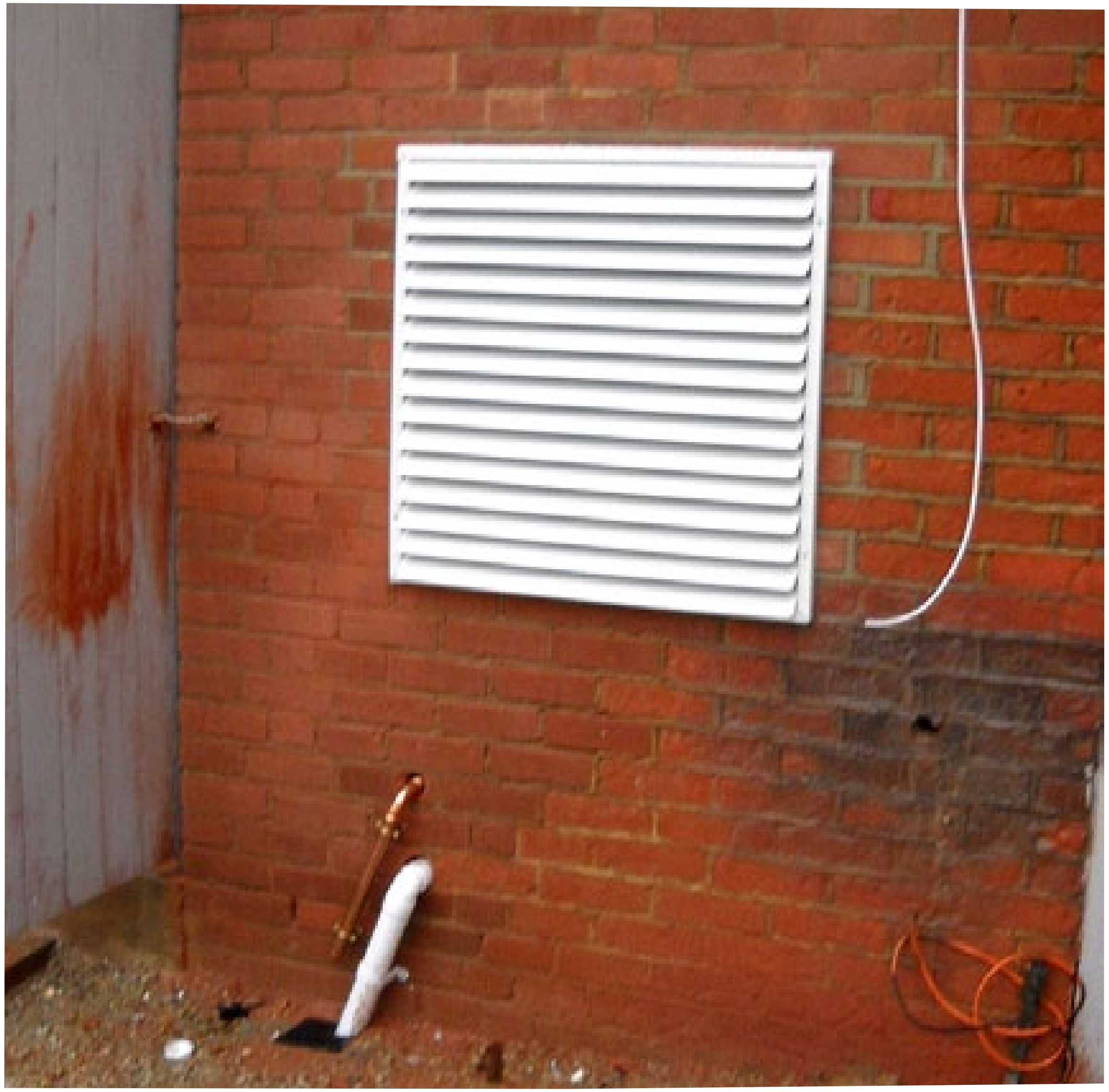
www.nationaltrust.org.uk/theneedlesoldbattery

If you require this information in alternative formats, please telephone
01793 817791
or email
buildingdesignguide@nationaltrust.org.uk

Case study information

Content: Charlotte Houldcroft and Paul Rayner
Design: Inkcap Design.
Images courtesy of: Paul Rayner and Charlotte Houldcroft

The Building Design Guide concept was devised by Rory Cullen and developed by Jonathan Howard with acknowledgements to Jacky Ferneyhough, Ingrid Chesher and Angela Collins.



Above **ASHP External discharge louvre during construction**