The fire strategy for protecting the innovative ‘cocoon’ at the Natural History Museum’s Darwin Centre is outlined by Andy Nicholson

HE NATURAL History Museum in London unveiled the latest part of its new £78m Darwin Centre last September. This state-of-the-art scientific research facility will not only be used by some 200 scientists at any one time, but also features public spaces to enable visitors to explore the natural world in an exciting and innovative way.

The architectural highlight is a gigantic ‘cocoon’ that safeguards millions of insect and plant specimens. At 65m long and eight storeys in height, the cocoon is the largest sprayed concrete, curved structure in Europe.

Located on the western side of the museum, the Darwin Centre was constructed in two phases, with the first part of the centre opening in 2002. The cocoon – part of the second phase – was designed by C F Møller Architects. Here, starting at the seventh floor level, visitors follow a prescribed route, stopping at interactive features which allow them to ask questions of the scientists at work.

The Darwin Centre also has the Attenborough Studio, a communication centre offering daily events combining innovative technology, specimens, live animals and natural history film footage.

The fire strategy had to consider not only the high volume of visitors and staff in the centre, but also the fact that the collections are unique and irreplaceable. Life safety, property protection and business continuity were equally important, as were factors such as security and environmental impact.
Relevant standards

Codes and standards provide a means to check compliance with the Building Regulations. However, the recommendations of fire safety codes are often developed in isolation and only focus on objectives for life safety or building protection. In addition, such codes are generic and it may not be possible to apply them to the unique nature of many large and complex modern buildings. This is the case for the Darwin Centre.

BS 5454: 2000: Recommendations for the storage and exhibition of archival documents, is widely used in museum design for fire safety. Compliance with its main recommendations is a prerequisite for certain buildings to be appointed by the Lord Chancellor for the deposit of public records or approval by the National Archives of the UK Government. However, the British Standard does not correlate to the unique collection of insects and plants at the Darwin Centre, nor does it consider the operational needs of scientists.

A published document from the British Standards Institution, BS PD 0024, provides guidance on the interpretation of BS 5454. In addition, in future it is possible that a new BS EN standard on archive documents will be introduced to cover changes in technology. It is anticipated that this will be much bigger in scope than BS 5454 because it will include art collections and museum collections, as well as documents. It may also cover climate and seismic conditions, which will greatly benefit the design of buildings such as the Darwin Centre.

The Darwin Centre was also subject to Section 20 of the London Building Act 1939. This requires additional fire protection measures to be incorporated into the building design, usually the provision of automatic sprinklers to safeguard firefighters.

Fire strategy

In order to achieve the aspirations of the architect and ensure that the life safety and asset protection objectives are considered, it is often necessary to deviate from codes and standards. A performance-based approach will include all relevant design inputs and assess the fire safety design of the building, based on its unique characteristics. For the Darwin Centre, performance-based solutions were used to satisfy, amalgamate and rationalise the requirements of Section 20, the Building Regulations in England and Wales, BS 5454 and the client’s aspirations.

Key to the fire strategy for this project was the development of sound fire engineering objectives that could be agreed with the many stakeholders. These included:

- developing a fire strategy that meets the legislative requirements for life safety (primarily the Building Regulations and Section 20) but also the protection of the collection
- considering the principles of BS 5454, but also the functional requirements of the museum, complementing the architect’s intentions and maintaining a fundamental level of safety
- developing a strategy in close consultation with all relevant stakeholders, especially the scientists (the end-users). This ensures ‘buy in’ to the fire safety principles at an early stage and a smooth approvals process through design and construction
- providing fire safety solutions that are applicable to the nature and use of the museum, with consideration to capital and lifecycle cost issues
- developing a strategy with optimum fire safety management provisions, so that the fire strategy is upheld through the life of the building

There were many interested parties who were regularly consulted on design issues. Key stakeholders included the museum’s scientists from departments of entomology and botany; its health and safety and fire safety manager, engineering department and curators; external fire, building services, fit out and security consultants; Royal Borough of Kensington and Chelsea’s Building Control department; the London Fire and Emergency Planning Authority; and the independent approved inspector.

Good architecture can only be achieved as a result of an open dialogue between all members of the design team. Of the many stakeholders, key members were the museum’s team, including the fire safety manager and scientists, since they had a fundamental understanding of the estate, operations and collection. Involving these parties in early design decisions prevented difficult issues, which are sometimes not resolved during design, being passed on to often absent end-users, which can lead to onerous operational responsibilities and inflexibility.

Qualitative assessment

Risk assessment is a key part of the BS 5454 guidance, with the assessment process examining the likelihood of fire in the collection and the consequences. From this flow recommendations for passive and active fire systems, or positive staff actions to reduce the risk to as low as reasonably possible.
In order to carry out a probabilistic risk assessment, it would have been necessary to obtain specific data on the number of fires that occur within the museum and the number of buildings over a period of time. Although the formal recording of fires in the museum is relatively recent, discussions with the museum’s estates, engineering and the fire safety manager showed that, over the past 12 years, there were only three fires on record. These were deliberate fire setting, where the fires were started in remote places in the museum (remote due to the high levels of security) and were contained at an early stage with limited damage.

Considering the small amount of statistical data, a comprehensive qualitative risk assessment was carried out for the Darwin Centre, using a qualitative scale to represent the perceived risks. The outcome determined whether additional mitigating measures were necessary.

**Collection methodology**

It was important that the risk assessment separated the collection of insect and plant species from the remainder of the centre, so that the genuine risk from fire to the collection could be evaluated. In addition to the assessment for the cocoon, a fault-tree risk analysis was undertaken, with specific reference to the storage of ethanol for an adjacent area in which hydrocarbons are used for specimen storage.

It was important to follow a logical process for considering the threat of fire to the collection. Buro Happold, using its experience from the design of the Grand Egyptian Museum in Cairo, the British Museum Great Court project and the Scottish National Portrait Gallery, developed the following methodology:

**Prevention:** Ensuring that a fire does not occur by controlling ignition sources and materials/fuel sources in the space. This was influenced by the management of the building and is a protective approach to fire protection of the collection. The creation of the prevention strategy involved the museum’s security consultants and response team. It was also necessary to detect any fire long before flaming combustion commenced, and so the use of very early smoke detection was included.

**Communication:** Ensuring that smoke detection is communicated properly to the fire safety team, so that they can investigate appropriately.

**Response:** The response of management is critical to ensure that appropriate actions are taken. This will be written up in a management response plan, based on the level of risk indicated by the detection systems.

**Extinguishment:** Ensuring that the fire can be extinguished quickly and with minimum consequential damage.

**Containment:** Containment of the fire and combustible products to limit damage to the building and specimens.

**Business continuity:** Having systems in place, such as a disaster recovery plan, salvage techniques and clean-up processes, to limit the impact of a fire on the museum and reduce the overall damage to the collection.

**Suppression systems**

When considering contents protection in buildings, the most common approach is to install an automatic sprinkler system, which will usually extinguish a fire and certainly control it to a size suitable for extinguishment by the fire service. This is recommended in BS 5454 and Section 20. For special collections, it is necessary to explore alternative systems which may be better.

However, suppression was not part of the initial brief for the museum, its estate was not generally protected by suppression, and there were no extra requirements from insurers.

As part of the trial designs under the performance-based approach, it was necessary to investigate the advantages and disadvantages of suppression, so as to enable the design team, and more importantly the museum, to establish the optimum package of fire safety systems and procedures for the collection areas. The risk assessment process was used to inform the matrix.

**Fuel load assessment**

When considering the effectiveness of each of the suppression systems in a matrix, the important aspect was the nature of storage of the collection. A relatively small number of sample specimens – usually trays of insects and plants – would either being studied by scientists in the laboratories or in public spaces for display and learning. The majority of the collection is stored within cabinets in 2-hour fire-resisting compartments within the cocoon. So, in terms of overall risk, an assessment of the inside of the cocoon and cabinets informed how a fire might develop and whether any suppression system would be effective.

Historically, the collections were stored in timber cabinets, with timber trays containing the collection neatly placed within the cabinets. However, the trays were of a reduced thickness to
the cabinet, so ignition would be easier than the solid timber frame. Also, the trays were stacked in vertical orientation, with the front open. This allowed air gaps between the trays, which would readily supply oxygen to a fire. Furthermore, the hydrocarbon naphthalene, which was used as a deterrent to insect pests, had soaked into the timber over a number of years. This would have an adverse affect on fire development. Clearly, the timber cabinets presented a significant combustible load, in addition to the collection itself.

The assessment for the cocoon also addressed the architectural finishes and furniture – no other furniture was placed in the space and the finishes were Class O non-combustible, in accordance with BS 476-6: Fire tests on building materials and structures. Method of test for fire propagation for products and BS 476-7: Method of test to determine the classification of the surface spread of flame of products.

Accidental fires and arson

The assessment found that any accidental ignition in the Darwin Centre was most likely to come from faulty equipment of mechanical and electrical services. As a result, the building services strategy, including equipment and facilities, was limited to: lighting power supplies (fluorescent tubes) at high level, complete with passive infrared control; 240V sockets at low level only for use of cleaners’ equipment, so discouraging staff from bringing in unchecked electrical equipment, such as laptops and microscopes; the electrical supply to fire alarm and detection system (and the use of fire-rated cables); the electrical supply to security systems, closed-circuit television (CCTV) systems, swipe cards and magnetic locks; and general supply and extract for the space via 2-hour fire-rated risers.

Considering the history of fires in the museum and with access to certain areas available to the public, deliberate ignition does pose a threat. However, the use of the centre has a number of control measures to reduce arson:
- doors have security access control, allowing only authorised staff to enter
- public entering the building will only have access to the ground, main, fifth, sixth and seventh floor levels, which are known as the ‘explore tour’. These areas are outside of the 2-hour fire resistance of the cocoon. Any member of the public that has special visitor access to the cocoon is accompanied by staff
- open-plan ground-floor atrium space gives staff a good visual view of occupants in this space, allowing them to see any malicious acts
- parts of the building also include CCTV, which is linked back to the site-wide security centre

As assessed, the ignition sources had been removed or mitigated to as low as reasonably possible and the oxygen concentration in the room was standard – meaning combustion would be sustained but not accelerated. But, while there was no furniture or materials of construction which presented a fuel load, the storage of the collection in naphthalene-soaked timber cabinets was unacceptable. A suppression system would be needed to control potential fire development if a security breach or unlikely accidental ignition occurred.

Pest management

Running concurrently to the fire risk assessment was a pest management strategy, developed by building services and environmental engineers. Insect pests are seen to be the single largest risk to the collection. According to BS 5454, ‘unsuitable environments damage documents more extensively than any other single factor’.

In addition to specifying temperature and humidity conditions in collection areas and areas where specimens are to be studied, the pest management strategy involves the use of storage cabinets to provide a permanent barrier between the collection and any pests that may cause damage. Metal-encased storage compactors mounted on metal bases, which run on steel rails set flush into the screed of the floor, were selected. These airtight archive storage systems also protect the collection from atmospheric conditions, including light, temperature, humidity and fire.

The likelihood of a fire within the cabinets, or the cabinets themselves being involved in fire, had been greatly reduced and so the stakeholders agreed that the effectiveness of a suppression system would be limited in this situation, considering the full package of fire safety measures provided.

Museum challenge

Developing fire strategies for museum buildings present some interesting challenges for the fire engineer. Artefacts and collections can be locked away in fire-resisting archives as a simple approach to fire safety, but protecting our heritage from the effects of fire, while complementing the architectural intention and allowing the building to be used by the employers or the public, is the challenge.

Using performance-based approaches based on a detailed risk assessment, and involving the stakeholders at the earliest stage, was key to the creation of a successful fire strategy at the Darwin Centre. If the end-users are consulted throughout, it means the building or the collection can be used in a day-to-day operation, while maintaining a fundamental level of safety, so that the collection and our heritage can be enjoyed for many years to come.

Andy Nicholson is an associate director at Buro Happold