Sanatorium Zonnestraal

the history and restoration of a modern monument

NAi Publishers

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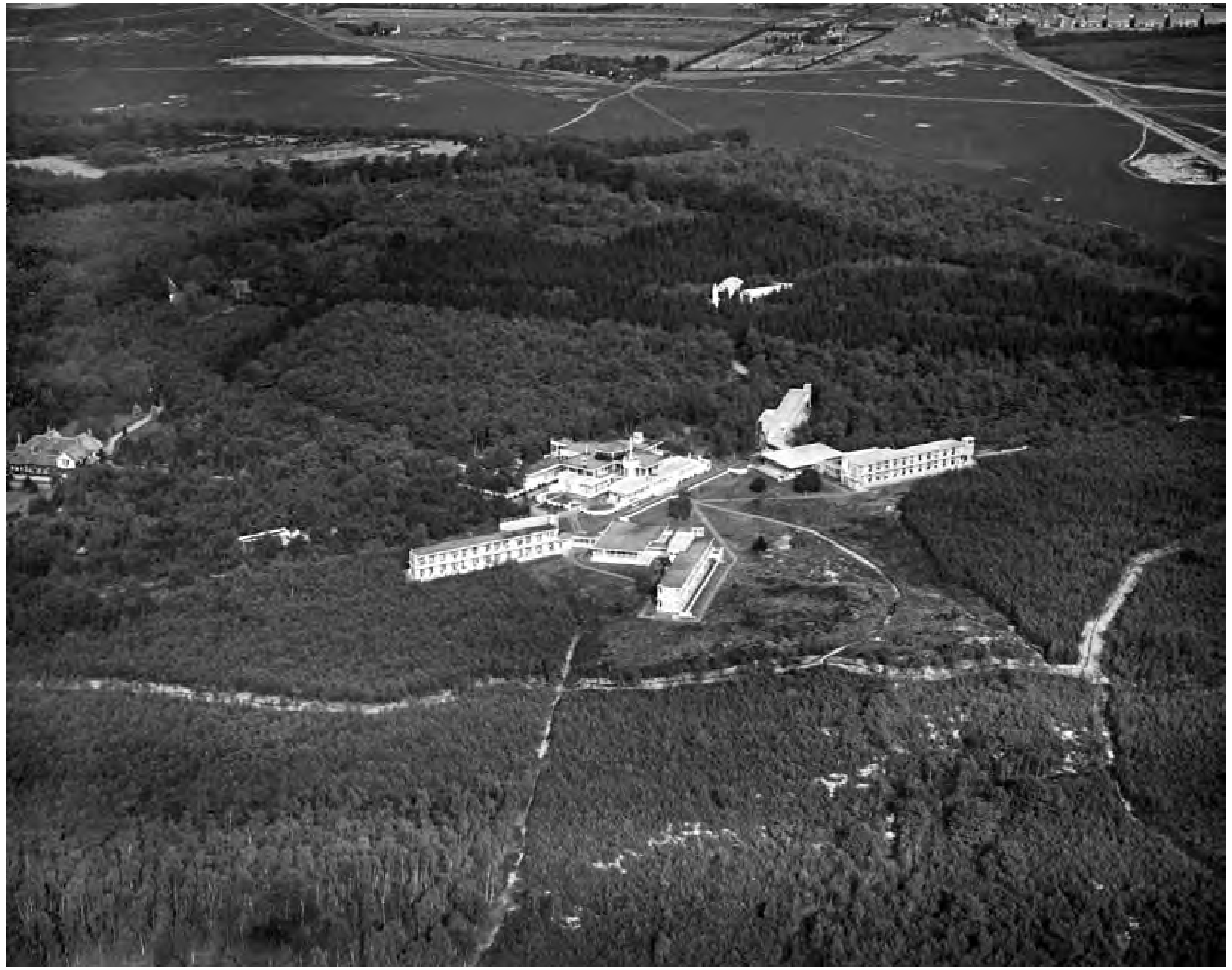
˅ Main building after the restoration in 2003.

˄ Main building in 1928.

< Zonnestraal after the completion of the Dresselhuys Pavilion, ca. 1931. There is still an open landscape with heath south of the sanatorium.

Contents

< illustration The Ter Meulen Pavilion during construction, seen from the entrance of the main building, ca. 1928. Left the perpendicular wing, right the conversation room.



sen lake area), the Zonnestraal estate and, finally, the Duiker complex and adjacent buildings. The first two levels of planning are addressed below.

Poort Egelshoek
The Landscape Plan restores the complex's original position within its surroundings. North of the main building coniferous trees will be planted in the open spaces created by the removal of the barracks in the 1980s and 1990s. The introduction of pine and oak will provide a more distinct identity, allowing it to serve as a uniform backdrop, the plantation, to the range of buildings along its borders. By removing trees and bushes in a radius of roughly one hundred metres from the balcony of the main building, an open space will be created south of this building, in which area, directly bordering the built-up zone,

12 Zonnestraal after the completion of the Dresselhuys Pavilion, ca. 1931. There is still an open landscape with heath south of the sanatorium.

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the heath can be brought back with peat cuttings. The birch tree, which can be seen in the very first photographs of the main building, will be preserved. When approached from the spider's web of paths south of the complex, the main building will once again emerge gloriously.
Some of the undergrowth will be removed in the remaining part of the sand dune area, and the trees thinned out. It has been decided not to create any sightlines in that part of the estate. That was not done in Duiker's time either, though what was particularly important was the sense of air and openness from the patios and balconies of the main building. From Bosdrift, the cycle path to Hilversum, the complex can occasionally be glimpsed between the trees.
In future that part of the estate may be added to the Hoorneboeg grazing unit of the Gooisch Natuurreservaat (Gooi Nature Reserve); the fence would be moved to the edge of the open space, immediately south of the main building, and run parallel to the original 1702 cattle bank. A new turnstile will allow ramblers to re-enter the estate at the end of the Bosweg, from the Hoorneboeg Heath. Large grazing animals will continue to shape the ecologically attractive alternation between open and dense parts of the sand dune area.

The Zonnestraal Estate
Major interventions are needed in the areas of access, parking, street furniture and lighting. The current chaos does not do justice to the estate's future status. Clean up and start again is the word. New buildings should ease rather than increase parking problems on the estate. The original access route should become the backbone of the estate again.
The entrance to the Zonnestraal Estate will be given more space. In an effort to enhance the visual sense of openness, the trees will be thinned out to where the old Loosdrechtseweg used to be (now marked by a wooded bank) and undergrowth removed. The historic brick columns will remain in place. This will create a new introduction to the estate with respect for the past and opportunities for ecological development.
The access route leads to the main building and leads on to the other functions of the estate. The road itself will be narrowed, which should re-establish a sense of grandeur and force visitors to slow down, as befits the new meaning of Zonnestraal. A uniform system of signage and estate furniture will be deployed to guide visitors around the estate. The house style is distinguished, uncluttered and timeless.
The old system of woodland lanes will be restored while the various components of the estate, including the lanenbos wood, the plantation and the area around the Pampahoeve, will be more clearly demarcated. The result will be a single estate encompassing a host of characters.

4.3 The Restoration Concept

Wessel de Jonge and Hubert-Jan Henket

The decision to restore Zonnestraal, which runs counter to what Duiker himself might have anticipated, was prompted by the fact that the complex represents exceptional value within the large group of buildings produced by the Modern Movement in the Netherlands. Any other forms of documentation, including drawings, models and 3D imaging, would have failed to convey the full significance of Zonnestraal in all its facets of space, its relationship with its surroundings and the sometimes almost anachronistic relationship between its concept and materiality. At the same time it goes without saying that the preparation of a restoration concept for a throw-away building is a paradox; the team had to find a delicate balance between conservation and change, on both a conceptual and a material level.

The original state
The decision to aim for conservation and restoration is followed by the choice to show all phases of a building's history or to revert to the original; permutations of the two can be interesting as well. With modern heritage it is particularly important to convey the designers' way of thinking. So when it comes to unique examples of modern architecture such as Zonnestraal we want to preserve the building in its original state. Besides, later additions and changes were less the result of a conceptual architectural intervention than of pragmatic extension and major repairs, which is why, during the early stages of the survey process, the researchers were particularly interested in Zonnestraal's original conceptual architectural qualities, such as the overall layout, the sense of space and the design of the façade.
As more and more information surfaced about the experimental construction techniques, which underlined the apparent contradiction between the innovative architectural concept and the more conventional materials and building methods used for the interior, for instance, it became increasingly clear that the materialization was of greater significance for the buildings' historical value than had been anticipated.

Deliberations
The restoration concept for the Zonnestraal buildings was drawn up using the decision-support model developed on the basis of the Dresselhuys Pavilion in *Bouwtechnisch Onderzoek 'Jongere Bouwkunst'* (Technical Investigation of Younger Architecture) in the 1980s.[1] It explored the consequences for the building if it were to undergo restoration which was either entirely (model I) or not at all (model IV) geared towards preserving its original state, or if it were to undergo a restoration

that was based on one of the many intermediate solutions (models II and III).

The two extreme models, each of which is underpinned by entirely different yet consistent reasoning, led to relatively simple solutions and mostly good results. If, however, the minimal materialization of the original is abandoned for the benefit of a slightly improved technical performance then the solutions, as we shall see, become more complex and costly. The choice for double glazing, for instance, would have a snowball effect, prompting the need to insulate the façade columns, floor edges, etcetera in order to avoid thermal bridges. From the start it was clear that raising the energy performance to present-day levels could never be achieved without undermining the fragility of Zonnestraal.

An approach in which the running costs were to be lowered as well was found to benefit from preserving the building largely in its original state according to intervention model II, that is to say with minor, imperceptible improvements for more sustainable management.[2] The more this approach is abandoned in favour of the increasingly pragmatic restoration model III, the act of balancing the original quality and performance in use requires so many special solutions that the intervention costs, and hence the overall annual costs, rise sharply.

Function follows form

In view of Duiker's ideas about spiritual economy and the lifespan of buildings, the Structure Plan stated that the sanatorium buildings were designed in such a way that they can no longer meet the requirements of a modern-day health care programme. Besides, as a national landmark Zonnestraal is expected to be nominated for UNESCO's World Heritage List, which means that since 1993, when it was vacated, the complex's primary function has changed from a building that is in use to a monument. However, the conservation of a monument, now and in future, depends on the kind of use that enables sustainable management. So the adaptive reuse of Zonnestraal was to be based on a function with a programme that would be largely compatible with the original state of the complex and with the buildings' structural and physical performance. Any part of the programme that did not fit this brief would be projected in the new-build development. The expectation was that that would result in fewer deviations from the original state, which would benefit both the monumental quality and the financial feasibility. That said, it meant that Louis Sullivan's principle of 'form follows function', the byword of the Modern Movement, had to be reversed.

A differentiated restoration concept

At individual building level the choices were more complicated. After all, the three sanatorium buildings were very different in what remained of the original design and materialization. When it emerged that a full restoration would not be feasible for all buildings, it was stated in the Dossier that it would not be necessary to restore all the Zonnestraal buildings in detail to their original state and that a differentiated approach could be adopted for each building.

The main building

At first the original concept of the main building outweighed the original material form of the building as it stood. Little appeared to be left: except for the concrete frame and two recovered partitions, attention focused mainly on the remaining architectural characteristics and aspects of the basic layout. When the researchers received the go-ahead for destructive surveys they found a great deal of information about the original materialization behind the lowered ceilings and facing walls, including a complete section of the façade.

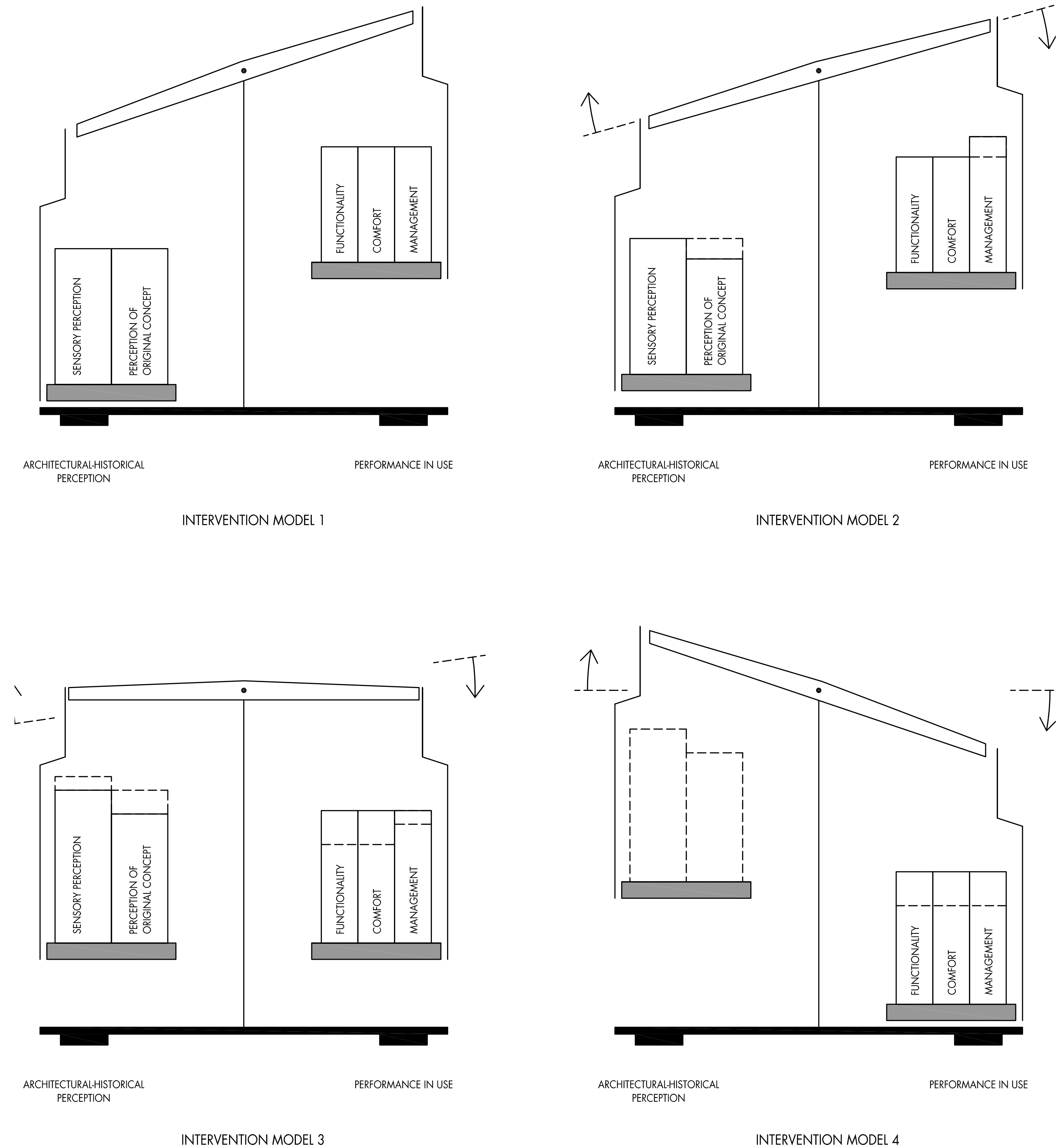
The approach to the main building would therefore combine models II and III: broadly back to the original state, but with a pragmatic slant and with the greatest efforts to remain as close as possible to the original building, use of materials and detailing. Model calculations had already shown that this combination of conflicting objectives would require major investment.

Because the concrete frame and a small part of the façades were almost all that remained of the first phase of construction, this approach involved a great deal of reconstruction. The pragmatic slant, for instance, is reflected in the acceptance of deviations from the original state in the case of essential functions such as disabled access, deemed acceptable because the many more original features at the Dresselhuys Pavilion would enable the pavilion to undergo a more conservative restoration according to model II. This was made a condition for the approach to the main building.

Given the ambitions to restore the ground floor to its original configuration and to reopen the northern passage, the functional programme required clustering so that future uses on either side would not interfere with one another.

The Dresselhuys Pavilion

Calculations made in the 1980s showed that the concrete frame of the Dresselhuys Pavilion had theoretically collapsed. Demolition and reconstruction with contemporary concrete technologies would be the cheapest method of 'preservation'. Despite the scarcity of original materials, such a



13 Four theoretical levels of intervention, each with a different balance between architectural historical value and use. The balance in model I is in favour of the architectural historical aspect. In model II more importance is attached to use than in the first model. Model III is in equilibrium, but there appear to be several ways of achieving that equilibrium. In model IV no importance is attached to the architectural historical value; it is the opposite of model I.

replica would probably do the greatest justice to Duiker's original design approach. After all, at the time repairs were possible only with visible thickening of the construction. Otherwise the partition walls would retain their unintended structural function, at odds with the original ideas about support and separation and would make it harder to adapt the internal layout in future.

When the research got underway in 1982 both the interior and the exterior of the pavilion were still largely original, albeit that the exterior was already in a very poor state. Although later research has shown that some of the terrazzo floorings were not original and date back to 1956 and that there have been some other minor changes, this pavilion – the only one of the sanatorium buildings – features mostly original materials and finishes,[3] which is why reconstruction was abandoned in favour of preservation and restoration according to model II.

The Ter Meulen Pavilion

The radical transformation carried out in the 1950s robbed the Ter Meulen Pavilion of its spatial and architectural character. When the covered terraces were closed off the subtle transition to the natural landscape was lost. The stairwells, the steel window frames, the end elevations and the interior layouts were completely replaced. This building is unlikely to have many original materials and finishes left.[4]

As the least original of the three buildings the Ter Meulen Pavilion could simply be preserved as part of the overall complex, which would require the building to be restored to its original outline with its balconies, roof overhangs and stairwells and to its original external appearance.

Workshops

The workshops and sawdust extraction tower reflect the economic principles of the aftercare colony. Unfortunately, the original façades of the three oldest workshops had been replaced in their entirety shortly before the survey got underway. Most of the basic layout, supporting frame and architectural elaboration were original, unlike the materialization and detailing.

It was decided to approach these workshops in the same way as the main building. For the exterior this meant a balance between the original state and discreet interventions for the benefit of adaptive reuse. For the interior such an approach could not be combined with the required programme, thus prompting a more pragmatic approach according to model III. The fourth workshop was merely valued for its position within the complex. It was decided not to develop the fifth position, which would have

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complemented Duiker's finger plan, because there is no need for such a building.

Materiality

The original state of Duiker's design in terms of planning, architecture, function, techniques and materials has been taken as a reference for the restoration of the sanatorium buildings. Early indications suggested that for practical and/or programmatic reasons restoring the buildings to their original state was not always entirely feasible. The guiding principle, therefore, is a hierarchy in which the building's conceptual originality is prioritized over the originality of the materials used during the restoration process. But Duiker's quest for new, specially designed technical solutions and materials – such as the prototypical curtain walls – suggests that the immaterial architecture that he aspired to called for major innovation in materials and construction techniques. This relationship between materiality and immateriality is the reason why, on second thought, it was decided to attach great value to the few remnants of Duiker's technical innovations. The remnants that were salvaged during the fieldwork give a reliable idea of the buildings' materiality. Exposing his experiments in building technology was therefore adopted as one of the principles underpinning the restoration. The advances that can be seen in this area between the first building phase of 1928 and the completion of the Dresselhuys Pavilion in 1931 is an important aspect here. A faithful restoration of the original state of both should shed light on such differences.

Model II is the guiding principle for the restoration of the Dresselhuys Pavilion. It allows minor, imperceptible technical improvements for the benefit of sustainable use, such as easing the thermal bridge effects by inserting thin strips of insulating material underneath the plaster. The approach to the main building and the first three workshops veers more towards model III, making the limited use of, for example, special insulating glass acceptable. With a view to manageable running costs, after 2003 the planned approach to the restoration of the carcasswork of the Dresselhuys Pavilion was relaxed in favour of model III, most notably by also allowing double glazing in its rooms.

Machine-made vs. handmade

Duiker's aspiration towards the immaterial, which epitomizes his buildings, shows a more nuanced picture in reality. Despite the appearance of mechanized production much of the work was done by hand; the plaster façades are a case in point. This contradiction is reflected in the way the form of the original substance is perceived. From a distance it evokes an image of mechanized production, whereas up close the traces of craftsmanship can be seen and are qualities that must not be lost through restoration.

Another paradox, that most of the industrial products of the time are no longer manufactured, usually means that alternatives have to be found, which can have an impact on the way the original form is perceived. Where possible, the difference between handmade and machine-made products and materials should remain visible. Because present-day mechanized production is characterized by a much higher degree of perfection some contemporary products, such as window panes and glazed tiles, can look 'too good' to routinely replace machine-made products from the 1920s. It is yet another indication of how essential the material quality is for Duiker's immateriality.

14 The parapets turned out to be reinforced with wooden battens that are not to be seen on any of the drawings.

15 The same wall seen from the other side. The wooden battens are placed at distances of roughly 30 cm.

16 Wooden dowels were embedded in the concrete to attach terrace railings or, as here, light fittings. This produced weak spots in the concrete.

Building services

Another challenge is that the Zonnestraal buildings were designed at a time when energy performance was seen in an entirely different light than we are used to since the energy crises of the 1970s. Besides, the buildings were targeted at users who were advised to keep their windows open at all times, even in winter.

Duiker and his consultants also developed a few original solutions in the field of climate control. Respecting these is even more difficult than respecting the structural components. After all, the buildings' new function differs greatly from their original one, while users also demand a lot more comfort these days. The situation is similar for artificial lighting and data networks.

Nonetheless, the aim of model II restorations is to install the new unavoidable systems in such a way that they are barely visible. Model III stipulates that the new systems must be neutral and preferably as unobtrusive as possible. What goes for all cases is that it should still be possible to decipher the reasoning behind the original solution.

Design

If departures from the original state are inevitable, any conflict with the architectural appearance as Duiker realised it, must be kept to a minimum. The same applies to the interiors and fittings.

For minor and incidental interventions, such as additional partitions and doors, or a slightly different layout the restoration team opted for a design that is true to the original appearance. The design of what are obviously new functional additions, such as the lift in the main building and the sheltered walkway between the workshops, is contemporary yet neutral. Here too the bar was raised for the Dresselhuys Pavilion compared to the other buildings.

Temporariness

The biggest restoration challenge however was to find a solution to the deliberate temporariness of Duiker's original design. On the one hand this refers to the sometimes strict configuration of building parts that was tailored to the initial period of use only and poses functional restraints for new use. The passageways in the main building are a case in point, where the idea of temporariness is so essential to the original design that here too function must follow form.

The second aspect was the transitoriness of the original technical and structural detailing. In the past the high maintenance requirements, in both intensity and frequency, could be met only because they were made part of the occupational therapy programmes. Now that such programmes are no

17 The western elevation of the square wing of the Dresselhuys Pavilion shortly after painting. The rich texture of the plastered parapets is striking evidence of work done by hand.

longer an option, the inevitable result is higher maintenance costs, which have an adverse effect on running costs. The same can be said for the extremely poor energy performance of the buildings in their original state. Now that the windows can no longer be left permanently open and the indoor temperature is expected to be 21°C in winter high energy use is unavoidable. To make the running costs manageable for the client they must be expressed, where possible, in monetary terms so that it can be agreed which party will be responsible for them, though this does not solve the problem that sustainability here remains the opposite of transitoriness.

4.4 The Restoration

Wessel de Jonge and Hubert-Jan Henket

When, after years of wrangling, the restoration of the main building and the three workshops was finally given the go-ahead, there was no stopping it. A restoration plan had to be drawn up immediately before the suspended field research and the historic building survey had even been completed. To get round the gaps in the restoration plan, a rather general restoration permit (*monumentenvergunning*) was granted. A Task Force of representatives from the municipality, RDMZ (Netherlands Department for the Conservation of Monuments and Historic Buildings), the client, the project manager and architects worked out the missing parts of the restoration plan. These were reported in the form of dossiers containing the relevant building-historical data, a restoration proposal and its consequences expressed in quality, time and money. Where paper fell short, for instance for the special glazing, additional field tests were carried out. Only if the Task Force failed to reach agreement would the steering committee step in with a final decision, as happened in the case of the costly re-creation of the linoleum. Although the restoration of the carcass of the Dresselhuys Pavilion was not carried out under time pressure the dossiers method was considered a success and continued.

The main building

Both the interior and exterior of the main building were completely restored between July 2001 and May 2003.[1] The restoration's primary goal was to return the building as close as possible to its original state, in both the original design and its materialization. On balance, the sole remnants of the first building phase were the concrete frame and an original part of the façade, both of which were carefully restored. The other work centred largely on the reconstruction of much of the original floor plans, façades and finishes. As a result of the decision to make the necessary concessions to ensure that the management of the building would be economically viable and sustainable, there were some departures from the original state, including some variations in the floor plans, the special insulating glass and the contemporary climate-control systems in the workspaces.

Programme

The decision to contract a number of individual tenants from the paramedical sector rather than a single user fitted quite well with the specific layout of autonomous wings and two passageways, allowing the northern passage and the turnabout to be reinstated.

The original internal layouts were taken as reference and found to fit well with the programme for adaptive reuse. The original direct link between use and the

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18 The demolition of the day clinic designed by the architect J.P. Kloos in the 1960s brought to light an original façade fragment that had been preserved between two partition walls, making it possible to determine many original details and colours.

19 After the dismantling of the main building, little remained but the concrete skeleton, a few partition walls and parts of façades.

height of the parapets was taken as the guiding principle for identifying a suitable function for every single room.

At the building's extremities and in other prominent places the building has several entrances with cloakrooms and washrooms, for the use of the various tenants wich can be made as emergency exits. Seen from the surrounding area the internal layouts are virtually identical to the original state.

Duiker's floor plan was only changed when a new function could not be accommodated. The former dispensary, for example, has not been reconstructed, creating in its stead a spacious lobby for a lift, necessary for disabled access. The lift-shaft cuts through the roof and opens out beside the end elevation of the upper hall, leaving the latter's volume intact. The hall itself, which is used as a conference centre, can be divided into three by transparent folding partitions.

There was no more use for the industrial kitchen,[2] but a new exercise studio including physiotherapy treatment rooms was an ideal use for such a large space. Because of its position at the heart of the building its new use goes largely unnoticed.

Dismantling

The new layout, which formed the basis of the client's operating cost calculations, was based on the original layouts which had been pieced together from archival research, as the building itself had not been available for field research in time. This made the building's dismantling in 1998 such an important moment, as the demolition of the many extensions marked the beginning of an understanding of the building's original substance. When in 2000 permission was granted to remove the floor coverings and ceilings as well, the presumed position of the partition walls could finally be verified by the concrete rebates beneath the concrete floor slabs into which the walls had been slotted. The research confirmed the kitchen wing layouts and the contours of the projection booth in the upper hall. Other construction traces yielded more information about the materialization and finishes, such as three original partitions and remnants of steel window frames, roof coverings, stuccoed ceilings and a piece of the cement borders around the linoleum flooring on the basis of which all the rendered borders could be reconstructed.

Concrete frame

It was only following the dismantling that the fragility of the concrete frame of the main building became apparent amid the ruins. Because of continuous use most of the concrete had enjoyed an indoor climate so the condition of the supporting structure did not disappoint. According to structural engineer ABT the replacement of a single girder and some repairs on two others was all that was needed. Four round concrete columns beneath the central part of the upper room, which had been added during construction because of cracking of the concrete frame, were replaced by steel columns filled with concrete.[3]

All the concrete was sand-blasted and repaired with classic methods: the defective concrete was cut away, the reinforcement depassivated and new mortar was applied, based on pure cement to prevent thermal expansion differences with the old. The original thickness of the render was used instead for an extra layer of sprayed concrete to ensure sufficient coverage and strength. With a thin layer of stucco covering the sprayed concrete any difference with the original is barely visible.

To satisfy the requirements for its new use as a meeting room, the floor of the upper hall has been structurally reinforced with a compression layer of some 70 mm. The heating, cooling and electricity pipes could also be incorporated into this layer, though with difficulty. Through lack of time and money the demolished projection booth, which was originally of reinforced concrete as well, has been brought back in outline only and executed in a timber, plasterboard and stucco.

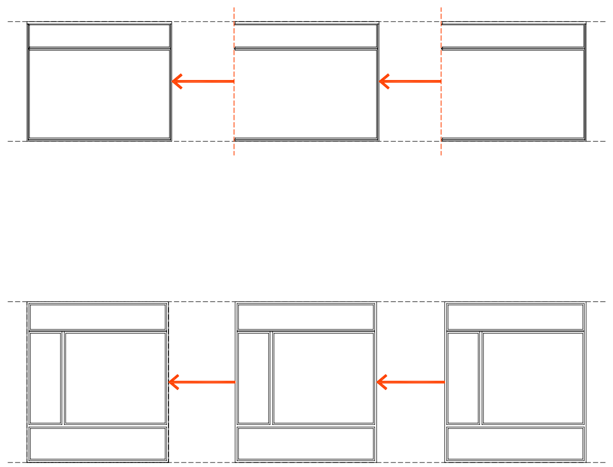
20 Destructive investigation could not start until late in the preparations for the restoration. The lifting of a ceiling panel revealed traces of an original partition wall that had been slotted into a relate in the concrete constructions above.

21–22 After the removal of the lowered ceilings, it was possible to read off the layout of many zones from the concrete rebates. Here the contour of the projection booth that was demolished at some point in time and the opening of the earlier ventilation system of the kitchens that had been filled in.

23 The hypothetical wall layout in the former kitchen wing could finally be verified, including the diagonal placing of the original food lifts. Repairs to the concrete skeleton in the central part of the main building, which were known from the correspondence between Duiker and Wiebenga, have become visible. Cracks in the supporting beams had been reinforced with steel braces and given extra support by four circular columns.

24 Detail of the restored, original façade of 25 mm profile steel. A single T-jamb appears beneath the two adjacent top hung sash windows.

25 A similar detail of the new, reconstructed façade of 32 mm steel profile. The two L-shaped side jambs of two adjoining façade elements again form a kind of T-jamb, but with 3 mm clearance in between, which has been filled with a sealant.



26 Diagram of the assembly method of the façades of the first stage of building (top) and of the Dresselhuys Pavilion. In the main building each of the frames shares a side jamb, leaving almost no clearance. In the Dresselhuys Pavilion complete façade elements were used that can be placed independently of one another.

27 During the dismantling, of the main building a comprehensive record of the hardware was kept. Many of the industrial products of the time proved to be no longer available and have been replaced by modern equivalents.

Infills and finishes

While the easy restoration of the concrete frame exceeded expectations, the infills and finishes did not. Some missing parts, such as the steel window frames and interior façade units, the drawn glass and the linoleum and terrazzo flooring, were carefully and expensively reconstructed. A number of products, including window hardware, were mass produced in the 1920s so that Duiker could simply order them 'from the catalogue', but as their production has since been discontinued replicas would now have to be hand made. All components for which a fairly similar standard model was available were therefore replaced with a contemporary factory-made product. Because nothing could be found for the handles of the remote control unit for the transom lights these were eventually reconstructed on the basis of a salvaged original.

Façades

Extensive preliminary research revealed the original layouts of the façades in considerable detail. The discovery of an original part of the façade in the administrative wing following the demolition of Kloos's 1967 extension of the day clinic confirmed the final details in 1998, including the original window hardware and the colours of the paintwork. That part of the façade could not be preserved where it was found because the double glazing that was a condition of the adjacent work-spaces, could not be fitted into the 25 mm profiles.[4] Once dismantled and repaired it could be replaced in the corridor to the right of the main entrance, where single glazing was acceptable. In that part of the façade the original INP 8 steel posts and the original, unventilated parapets with an inner and outer leaf of plastered metal mesh have also been conserved, so that we can speak here of a fully authentic materialization.

The posts for the reconstruction of the façade were still available, but the manufacture of the window profiles had been discontinued.[5] Besides, the shallow steel profiles were known to have caused problems during the first building phase, which is why Duiker used the much heavier 40 mm profiles during the second phase.[6] With this in mind the 32/37 mm series was chosen for the restoration, which may be slightly heavier than the original window profiles, but is still clearly different from those of the Dresselhuys Pavilion. The deeper profiles allowed the retention of the characteristic sharp putty framing, even when using insulating glass.

The original façade system consisted of prefabricated elements, although only the first window frame was installed as a complete unit. To save material, the other window frames were fitted with only a single side mullion and were then welded to the previous

28 In test cases the attempt has always been made to take into account an integral part of the building, as here a part of the façade from the foundation to the roof. The plaster, the finishing of the frames with alkyd paint and the glazing were evaluated.

29 Placing of the storm porch in the administrative wing by the frame supplier Van der Vegt, 2003.

30 Drawn glass causes distortion in the view both looking outside from inside and, as here, looking inside from outside. The texture of this glass makes it more tangible than modern types of glass.

31 The testing of the window panes in the corner of the large hall. The glazing was always tested on corner locations so that the view through two panes of glass could be evaluated.

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element to form a stable whole. At the level of the INP 8 profiles the window frames therefore share a single T section as a mullion. So in effect the elements form a continuous window frame of about 33 metres whose lack of dimensional tolerance undoubtedly led to problems during construction in 1928, prompting the decision to redesign the façade elements as autonomous units with an L-section on either side. As soon as two frames are placed side by side, the two L-sections form a kind of T. The frames have been attached to the vertical posts with clearance of just 3 mm. Upon close inspection, the slightly recessed joint sealant reveals which parts of the façade are reconstructions and which are original.

Underneath the new window frames the parapets have been reconstructed with porous brick (poriso) and given exterior wall insulation to improve thermal performance, finished with a mineral plaster. As its finish and paintwork are quite similar to the original, this solution is visually satisfying, even if the hollow sound when it is tapped is a clear indication of its new construction method.

The cement plaster has been finished with a mineral paint. On the advice of the RDMZ both the inside and outside of the steel window frames were finished with alkyd paint, which of all of contemporary products available bears the most resemblance to the original linseed oil paint.

Glazing

The main building is little more than a concrete ‘etagère’ enclosed by a light and transparent membrane. To recreate the perception of the original materialization as faithfully as possible the choice of glass used for the restoration was critical.

Zonnestraal predates the invention of float glass, which was brought onto the market by Pilkington around 1960. The ‘window glass’ which had been originally prescribed for Zonnestraal was drawn glass which was slightly warped and caused vertical distortions, giving this type of glass a more material character than float glass, essential for the transparency and reflection of the prototypical curtain wall of 1928. Because the use of the much more immaterial-looking float glass would have spoilt the perception of the shape of the main building, drawn glass was used for the restoration.

The clear drawn glass, which was a standard product in the 1920s when it was made of sand with low levels of iron, was eventually imported from Lithuania. In consultation with building physics specialist DGMR, it was decided to install single glazing in all the spaces that did not require careful climate control, such as corridors and stairwells. The same applied to large spaces such as the upper hall, where people can simply sit a bit further from

32 South wall of the main building, edge of the roof of the staircase with drip stains from melted roofing tar, 1930s.

33 At a later stage a plastered drip edge was applied to a large part of the building, which gave it a very different appearance.

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the glass façades to avoid down-draught and cold radiation. Because the cruciform shape of the room makes it possible to look diagonally through four glazed façades the colour of the glass was particularly important.

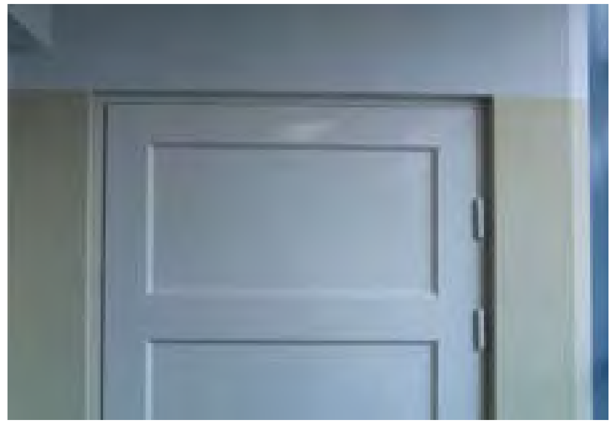
Single glazing was unacceptable for the workspaces. A special solution with 11 mm insulating glass was designed to meet the criteria of both comfort and original appearance. Because it was possible for single and doubling glazing to appear side by side, it was necessary to keep the differences in appearance between the two to a minimum. The decision to use the Lithuanian glass for the outer pane was a first step. To avoid any colour differences with adjacent single glazing the possibly even clearer Starphire float glass was imported from the United States for the inner pane. Contractor Jurriëns had it successfully made into insulating glass with a full guarantee.

Roofs

During the restoration the roofs were refitted with thermal insulation. Because many of the roofs are clearly visible from the upper hall, the aim was to recreate the original look as best as possible.[7]

The minimalism of Duiker’s architectural solutions is reflected in the absence of any roof edge detailing: the roofing was simply stuck on the stuccoed concrete roof edge and extended up to where it meets the stucco finish of the elevation. This meant that very shortly after completion the roof edges began to show signs of dirt and molten bitumen. In many places the roof edge was found to have a small concrete upstand, which was fitted later to combat this.[8]

The remnants of the concrete upstands were removed to restore the building’s appearance to that of the first building phase of 1928. The roofing was pulled over the roof edge again, although not before an aluminium strip was attached to which the roofing was fixed which reduces the risk of damage from, say, ladders against the roof edge. The joint between the aluminium strip and the stucco has been sealed with an elastic sealant.



34 Where no high sound-proofing standards apply, newly made panel doors have been used.

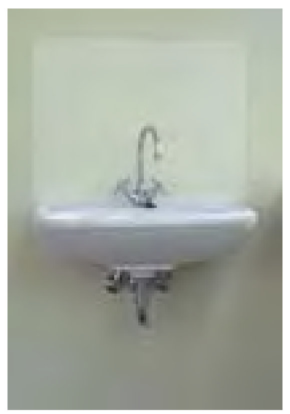
35 Where high soundproofing standards do apply, solid multi-plex doors have been used, to which panels have been glued with the same pattern as the original ones but in reverse.

Partition walls and interior doors

To prevent the partition walls from buckling where they meet the transom lights, Duiker had a wooden batten fitted just below the window frames while the building was still under construction; it was plastered along with the rest of the wall. During the restoration the question of how to adhere to the principle of a transom light while still achieving a structurally stable entity came up again. Erecting new partition walls in a plastered mesh construction is labour-intensive and costly, so the new walls have been made of 70 mm porous brick. Where they meet the transom lights they are, where necessary, fitted with a steel box section with a plasterboard and stucco finish in place of the original wooden battens. As a result the standard height of the interior doors is consistent with that of the outside doors, while in both cases the clear door height does not exceed 1.95 metres.[9] Like the transom lights and the interior glass fronts, the related inner door frames of steel profiles were reconstructed in the same way as the external window frames. A contemporary folded steel frame was used for the other internal doors.

Where no soundproofing between rooms was needed wooden panel doors similar to the original model were used. Sound-proof doors were made of solid plywood. With glued-on panels copying the panelled surface of the original doors, the difference between the two types of door is not very obvious.

36 Concrete enamel water-proof finish for the walls, which has been meticulously restored. Because the substrate is also different for today's wall plaster, careful planning was required.



The glass in the sound-proof transom lights has been made of a laminated variety.

Despite all the care that was lavished on the restoration, not all solutions are entirely successful. It only emerged afterwards, for example, that the use of two hinges at the top and one at the bottom of the inner doors is a contemporary convention, whereas back then it was just as common to have one of the hinges in the middle.

In 1928 the outer corners of the plastered mesh walls were protected with corner beads up to door height. Above, the manually drawn corners had much softer edges which, like the glass, emphasized the building's physical character. During the restoration the plasterer managed to achieve a similar look by covering the corner profiles. By applying the original picture moulding all over, users need not drill into the partition walls.

Concrete enamel and terrazzo

In 1928 the walls of sanitary facilities such as bathrooms and kitchens were finished with concrete enamel and the floors with terrazzo. The same principle was adhered to during the restoration.

Duiker called this type of wall finish by its product name 'fortoliet': a special water-proof plastering technique in which pure cement mortar is applied in two consecutive thin layers and the top layer is usually stippled with a brush to achieve slightly bumpy surface.[10] The same technique has now been applied to the dado of the sanitary facilities and the splashback behind the wash basins.

The inside of the parapets has been finished with gypsum plaster and painted. The water-proof finish of the original window sills with concrete enamel has been replaced by a special paint product which has been mixed to achieve the right colour[11] and applied to the inner walls of the sanitary facilities in a bumpy texture to match the dado of the partition walls.

Since no trace was found of the original terrazzo flooring the composition of the new terrazzo has been reconstructed on the basis of a remaining countertop from the Dresselhuys Pavilion. The original floors were installed without joints, but to avoid a repeat of the damage that occurred in the past, expansion joints were added on either side of all doorways and where it was technically necessary to break up large surfaces.

For reasons of cost and quality but also to highlight the difference between the original and the new layout, the walls and floors of most of the new bathrooms have been tiled.

Linoleum

As before, a linoleum finish proved suitable for the building's new function, in part because it met the requirements for antistatic flooring. Lacking information about the original types of linoleum, it was initially planned to use plain Waltons.It was not until long after the restoration process had got underway that it emerged that there had been three different colours of linoleum with a woodgrain pattern.[12]

Forbo, the original manufacturer, no longer produced Jaspé linoleum, but the German Armstrong DLW did, albeit not in the desired colour. The information gathered during the historic building survey justified the decision to opt for the two shades of brown that Duiker had ordered from the Forbo catalogue in 1927. The same could not be said for the third colour, green, given the uncertainty about its location and the absence of a reliable colour reference, prompting the decision to put in light and dark brown linoleum, for which there was sufficient evidence, throughout the main building and to accept that a medium brown shade would be used in rooms that may have had green linoleum.[13]

Although linoleum was commonly used in institutions to muffle the sound of footsteps, it was relatively expensive. Duiker saved money by using wide borders of white cement in places where nobody walked. The linoleum was put in the middle as a runner. To avoid waste the runners measure approximately 1 metre, almost exactly half the width of a roll. During the restoration the cement borders were manually fitted again and put up against the walls with a hollow skirting-board. Whereas back then, in a period of cheap labour, such manual work may have been economical, its excessive cost this time around confronted us with a curious paradox.

Building services and climate control

The climate control systems were a particularly important element of Duiker's design, as suggested by the almost ostentatious display of the boiler house, which showcased the steam-heating system in its full glory, and by the striking chimney with water reservoir and condensers which occupies a prominent position in the asymmetrical exterior composition. A less conspicuous but innovative system was that for the mechanical extraction of the kitchens and the upper hall. The scale of the other services was modest. Warm water was available only in the bathrooms and kitchens, lighting and other electrical equipment was used sparingly and there were only a few telephones.

One of the aims of the restoration process was to highlight the experimental services engineering. Where possible, the original principles were adhered to, although sometimes modified to achieve more sustainable solutions. New systems have been concealed or else applied in an inconspicuous and neutral way.

The original steam-heating has been replaced by a hot water system.[14] The model of the boilers and their installation in the boiler house are very similar to the original, while Kropman Installatietechniek has carefully designed much of the visible piping with the help of photos from the archive.

The reproduction of the pipe radiators proved to be a costly affair. The switch from steam to hot water also meant that the heat emission would be much lower than in the past. Nonetheless, the original appearance of the system was considered to be such a fundamental aspect of Duiker's design that, at least for the most public spaces, the original pipe radiators were carefully reproduced and placed along the walls of the entrance halls, corridors, stairwells and the upper room, and was technically possible because the circulation areas do not require very powerful heating. In the upper hall the pipe radiators along the

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37 Samples of the various wall and floor finishes are examined in the laboratories of the DLW factories in Germany .

38 The test samples are made by hand and evaluated.

glass façades double up as safety barriers. The room has also been fitted with additional under-floor heating connected to the cooling system in summer. Because of their small size, the strict climate conditions for paramedical use and the high capital outlay the workspaces were fitted with contemporary standard radiators or fan-coil units.

Whereas a window that opened might have been enough in the past, improved sealing of windows and new standards of comfort meant that a few functions also required cooling and/or mechanical ventilation. The air-handling installations were housed in the former underground storerooms in the kitchen wing; the cellars' hatches have been re-used as ventilation grilles. In the main hall the podium doubles as an air shaft.

Electrics

The lighting is based on the original lighting design. Both indoors and outdoors, replicas of the old light fixtures have been used.

The building used to be sparsely lit with sometimes just a single ceiling fitting per room, which would achieve a light level of approximately 75 lux. To meet today's illumination standards, the number of light fixtures had to be doubled or even tripled in most spaces.[15] As the original wiring had been integrated into the concrete floors, the extra electrical boxes could only be installed by cutting more than 400 holes out of the roof slabs. Only for the kitchen wing these could be fitted into the new compression layer on the floor of the upper hall.

Thanks to their relatively high number the opal glass shades of the original ceiling lamps could be remade at a reasonable price. The dark metal base was copied in dark-brown powder-coated steel.[16] By opting for a slightly larger diameter a contemporary and cheap standard PL fitting with base-plate could be used, which also allowed the integration of emergency lighting. The exterior lighting could be assembled from clear shades that were still commercially available and the porcelain base of another fitting. The painted metal cover was custom-made. As a result the replica fittings were not much more expensive than contemporary standard ones.[17]

Building management and maintenance

Some of the solutions will require extra attention from the building management when the main building is in use, including the fragile roof edge details, the horizontal stucco surfaces, the pristine white colour and the many sealed joints that will require constant maintenance. The special glass came with a small supply of extra panes, but the coloured sealant for the glass fitting can only be ordered in large quantities. The service systems are more fragile than normal. The condensation in the

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39 One of the few remaining ceiling lamps. The number of fittings has been considerably increased to obtain an acceptable level of lighting.

steel chimney flue, for example, requires regular anti-corrosive treatment. The government and the owner have made agreements about the responsibilities and costs, while guidelines governing tenants' use have also been drawn up.

The Dresselhuys Pavilion

It was not necessary to wait for the Dresselhuys Pavilion to be dismantled to assess its original state, as the building was still virtually intact. The experiences and expertise gained from the restoration of the main building could be used to analyse the relevant data and piece together a coherent picture.

The restoration of the Dresselhuys Pavilion had been planned to commence immediately after that of the main building in 2003. The collapse of the roof overhang of the square wing in 2001 had shown the urgency of restoration. But without a function or a buyer the finances for the necessary investments were not forthcoming, prompting the decision in 2007 to spend the accumulated subsidies on the restoration of the building carcass to make the pavilion wind and waterproof and avoid further deterioration. That work has since been completed.[18] The remaining work will have to be done at the expense of the owner, in which case it can be customised to the building's definitive function.

A restoration and building permit were requested for a comprehensive restoration plan, i.e. for the restoration of the building carcass and finishing, but without a functional use. By literally filling in "none" for the building's function the plan would not be evaluated against the requirements of a specific use while the function, and with it the requirements for use, had not yet been determined. The compulsory realization of all kinds of facilities during the works on the building carcass could thus be avoided, for otherwise a building permit could not be granted.

Concrete frame

The concrete structure of the Dresselhuys Pavilion was in a much worse state than that of the main building. Decades of dereliction, lack of maintenance and vandals breaking windows meant that both the inside and outside had been subject to outdoor conditions. The inferior quality of the original concrete mortar and the poor execution led to very severe reinforcement corrosion. Corrosion of the reinforcement bars had spalled the covering layer in many places, while other places had gone without cover since completion. As such the collapse of the roof overhang of the square wing was only a matter of time.

In addition to a few columns and girders the balconies and roof slabs of both wings and the connecting corridors also had to be replaced in their entirety. The roof slab of the lounge was partially

40 A standard window from the corridor walls in the Dresselhuys Pavilion. They were seriously damaged because this side was not protected by a roof overhang. Inadequate profiling meant that the window sills had folded upwards, often leaving the ground sills wet. The consequences can be seen from the swollen steel work of the sills.

rebuilt, while the remainder could be reinforced with a compression layer. The floor slabs that needed replacing were first fitted with tight formwork at the bottom and sides, after which the concrete was cut away. The reinforcement from the underlying concrete girders and columns was interlinked with the new reinforcement. Following the demolition work the formwork was first fitted with a rubber mat before the new concrete was poured to leave space for a layer of plaster in a technique that restored the concrete structure almost exactly to its original section.

As for the other concrete structures that could be preserved, including most of the floor slabs, girders, columns and bed-lifts, inspections determined which parts needed repairing. The bad parts were cut away down to the reinforcement and, depending on the situation and size, restored to their original shape with either spray concrete or manually applied repair mortar. Spray concrete was necessary in only a few places.

Calculations revealed that the resistance against sheer forces of the concrete girders underneath the ground floor and first floor were insufficient for the 9–metre spans. With a view to future use it was therefore decided to support the girders at 3 metre intervals. Although it contravenes Duiker's ideas about the separation of support and partition, the use of partition walls proved to be the most effective solution. One of the consequences, however, is that there is less freedom to modify the room arrangements later on.

Following the concrete repairs the exterior was finished in the same way as the main building. The interior finish is part of the completion phase and has yet to be done.

Façades

The historic building survey has shown how, in the three years between the initial building phase and the completion of the Dresselhuys Pavilion, Duiker continued to develop the structural detailing. The most striking examples are the steel window frames, which were made as separate façade units in the pavilion, and the segmented parapet construction. And whereas the main building had featured an unventilated cavity wall construction, for the second pavilion Duiker opted for a moderately ventilated version by fitting alternating ventilation grates and elbow pipes in the walls.

During the restoration it was discovered that the external wall leaf had been made on site of cement plaster on reinforcement bars. At most of the corners the original external wall leaves could be repaired and thus preserved. The somewhat battered exterior has been carefully preserved in order to show that the pavilion has a history. The other external wall leaves were so badly damaged that they had to be replaced by new ones drawing on the original, albeit improved principle.

In 1931 the external wall leaf was constructed first, so that the reinforcement could be properly rendered with cement plaster on either side before the inside of the cavity wall was erected and the cavity was closed. Most of this 50 mm sand-lime brick-on-edge course could be preserved, which was good given that there was some original plaster on the inside. As a result, the reinforcement of the new external

41 The new structure of the parapets. Right the original lime-sand inner cavity leaf. In the middle the new structure with (from inside to outside): cement rendering coat, cavity, thin insulation panel, galvanized steel reinforcement (not visible), stainless steel clayed wire mesh and cement plaster. Left the final result.

wall leaves could only be rendered from the outside and was partially exposed inside the cavity wall. Additional protection against corrosion now comes from horizontal zinc-coated steel bars, which were inserted through the holes in the INP posts, a stainless steel clay wire mesh and a zinc-coated steel reinforcement net on the outside. A slender insulating panel has been inserted into the cavity wall. The ventilation facilities could be reproduced and the air flow has been improved by making larger slots in the columns.

When the restoration got underway nearly the entire steel façade of the pavilion was still in place. Many of the posts could be preserved and restored while the damaged ones were replaced by new, virtually identical INP-8 profiles.

Where possible, the differences in detailing of the window frames compared to those of the initial building phase in 1928 have been respected. The technical state of the non-galvanized 40 mm steel profiles varied considerably. This is explained by their exposure to wind and rain and any protection they may have had from overhangs. Approximately 84 per cent of the frames could be preserved and repaired. The same 32/37 mm series was used for the replacement frames as for the outside doors in the main building, but adjusted to the 40 mm series by trimming flanges or assembling the profiles from fixed profiles and welded strips.

The disintegration of the bottom sills into a millefeuille of corrosive steel had been caused by the contraction of the sheet metal sill, which had been too thin and in which water had pooled. This is why new, tightly crimped steel weather sills have been installed underneath the window frames. The original, continuous profile has been replaced by two independent sections which have been thermally separated by a synthetic strip. Taken together the two parts closely resemble the form of the original window sill. Many of the window hardware could also be repaired and re-used.

Glazing

The specially developed insulating glass for the main building had been so well-received that it was decided to install it in all the patient rooms in the Dresselhuys Pavilion, even though it was not yet known whether this feature would be indispensable for the future end user. The aim was to increase the chances of finding a user who would contribute to a sustainable re-use of the pavilion. Besides, because of the closed wall of the corridor the factor of seeing through several windows at once is negligible here. The factory in Lithuania could no longer supply the drawn window glass, but contractor Jurriëns found a suitable alternative at a large German glass factory.

All the other spaces (lounge, corridors, service areas, toilets) have been fitted with single drawn glass.[19]

The workshops and extraction tower

The restoration of the workshops was completed in two phases. The first three workshops, which were built in 1928 and 1935, were restored at the same time as the main building and by the same team in 2002. The fourth workshop from 1940 and the 1928 sawdust extraction tower were renovated in 2006.[20] The colour palette of the workshops is dominated by the snow-white painted façade and the ochre-yellow window frames and doors.

To increase their potential uses as part of the estate and offer flexibility for the future, the first three workshops were linked by glass-covered walkways. They were designed as transparent glass covers with wind shields, resulting in a non-climate-controlled semi-outdoor space. The idea was to offer a sheltered walk from workshop to workshop with a largely unobstructed view between the workshops of the woods behind while retaining the impression of detached sheds. These sheltered walkways were also rented out as usable space, after which the open detailing of the glass structures was closed off in a makeshift way. Unfortunately the linking structures lost most of their architectural merit as a result.

Workshops 1, 2 and 3

The initial building phases were used as a reference for the restoration of the first three workshops designed by Duiker. Because the later building phases lacked any architectural merit, all traces of them have been removed from the buildings.

Although designed as part of a complex of five sheds the third workshop from 1935 differs from the first two from 1928 in form, construction, materials and detailing. The historic building survey, drawings and photos from the archives and analysis carried out during the dismantling of the buildings helped piece together an almost complete picture of the original state of both types. The underlying principle of the restoration was that the differences between the two construction techniques would be respected and where necessary reinstated. The latter was particularly important in the construction of the horizontal pivot windows.

The concrete work and timber structure of the two older workshops remained intact and in a fairly decent technical condition. The concrete parapet walls have only been painted and fitted with an insulating facing wall of plasterboard on the inside. Some parts of the timber trusses on top of this were substituted, as was the timber roof decking.

The remaining wood finish of the trusses and the ceilings was found to contain asbestos and removed. It was replaced by plywood painted to evoke the texture of the original material. The new ceilings were made of stucco on plasterboard and then painted.

The original flooring of concrete tiles on a sand-base was replaced by newly poured and insulated concrete floors. The brick underground air ducts in the original wood workshop were documented, carefully covered and preserved underneath the building.

A great deal of attention has been paid to the reconstruction of the original wood-framed pivot windows, three rows of which fill the longitudinal elevations. They fit squarely, without intermediate transoms.

The missing sliding doors in the end elevations have been reconstructed with their original detailing. Because the sheds were originally intended to be semi-open air spaces, the original structures lacked any sealing. For contemporary purposes, however, that was essential. To that end the sliding doors have been secured and sealed, but in such a way that the doors can be made to function again as soon as another use allows it.

In the third workshop, the pivot windows in the longitudinal elevations came in two rows without connecting transoms and consist of a curious combination of wooden frames partitioned by steel T-sections. In addition to archival material and traces of the construction history, it was possible to draw on a few original windows in the fourth workshop, which had been designed by Bijvoet with the same structural detailing.

The restoration approach to the third workshop was virtually identical to that of the first two.

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42 Documenting the underground air ducts in the carpentry workshop. They were covered with steel checker plates.

43 Workshop III has a differently shaped roof and differs in other respects from the first two workshops.

Workshop 4

Taking Duiker's design for the third workshop as a reference, Bijvoet designed the fourth workshop in 1939 which was completed in 1940. When the complex was nominated for heritage status, the building did not meet the age criterion of fifty years in accordance with Dutch law, so that it was excluded from listing. All the same, in 2006 it was decided to restore the fourth workshop, in this case inclusive of its past modifications, and to regard it as an integral part of the workshop complex.

This was achieved through minimal adjustments to the structural detailing in combination with major repairs. The colours of the exterior were inspired by the colour palette of the other workshops. The layout for the new function reflects the original situation, with smaller workspaces at the front and the requested larger space for a reception and a blood donation centre facing the woods. Most of the interior finishes were determined by hygiene requirements.

Extraction tower

The restoration of the sawdust extraction tower consisted largely of removing everything, including equipment, that had been added over the years and repainting it in its original colours: white for the stucco and aluminium for the metal components. Although not an original feature, the metal chimney pot of the central heating system was also included.

Afterword

The feasibility study carried out in the 1980s was used to define, in consultation with both the client and the RDMZ, a specific restoration approach for each building. A new use was found for the sanatorium buildings and the workshops which respected their status as listed buildings, although after

44 The central workshop after restoration. The light fittings are copies, as in the main building, and fitted with PL lamps in a warm light colour.

45 The longitudinal facades of all four workshops consisted of abutting pivoted sash windows without a middle rail. During the restoration it required a lot of patience and ingenuity to determine the details.

decades of dereliction the Dresselhuys Pavilion still awaits a new user.

The greatest possible attention was paid to the conceptual and material ramifications of Duiker's architectural approach. But what counts is that the buildings are back and that despite technical adjustments the fragile beauty of Duiker's masterpiece can be enjoyed again by the general public – albeit at the expense of functionality and development.

Two aspects of the restored buildings stand out. The first is the newly visible contrast between the dream and the reality of the materialization, the almost anachronistic relationship between concept and materiality, the differences in innovative construction techniques of 1928 and those of 1931.

The second is the renewed contrast between the innovative exterior and the much more conservative interior. The fact that that was respected during the restoration of the main building enhances the story that Duiker's creation tells us about the socio-cultural context of his time.

The restoration contributes to the historic continuity of our society and has won wide-spread praise. Even independently of its major architectural-historical value, the unique history of Zonnestraal has made it into an unrivalled symbol of Dutch social democracy. The interest from all over the world has been immense. On the occasion of Open Monumentendag (Dutch Heritage Day) in 2003 the recently restored main building attracted nearly 2,000 visitors in a single day.

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