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Toward Sustainable Environmental Control: Temperature and Humidity Control at the National Diet Library of Japan

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Abstract:

The key factor of the storage environment for prolonging the life of a library collection was once thought to be maintenance of the ideal level of temperature and humidity. Today, however, it is recognized that in regions with broad fluctuations in temperature, it is unrealistic to invest vast sums of money to maintain an even level of temperature and humidity in library stacks. Previously, the National Diet Library (NDL) Tokyo Main Library air conditioning system was operated throughout the year from 9:00 a.m. to 7:00 p.m. maintaining the stacks at 22℃ with a relative humidity (RH) of 55% until 2011. Following the discovery of large-scale mold infestation in the collection in 2007, however, the library reviewed its methods of temperature and humidity control.

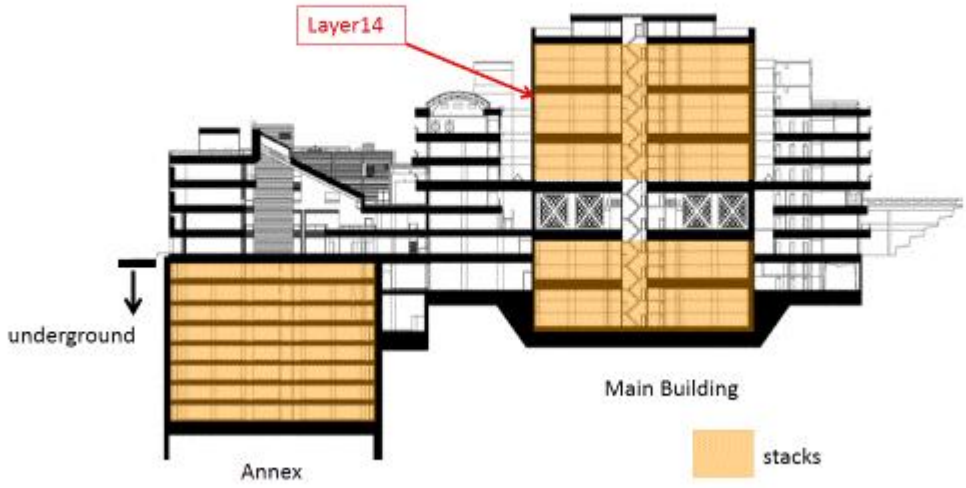
This presentation introduces the NDL project to set up an environment management system for the whole NDL and improve its storage environment. It describes the NDL's first experience of a large-scale mold infestation in 2007 and its efforts to eliminate mold the following year by monitoring temperature and humidity levels and regular inspection of the affected areas. Those efforts were continued through the establishment of an NDL-Wide Council for Environmental Control in 2009 and activities by its working group to counter the mold and high-humidity problem. The last part of the presentation describes changes in air conditioning operations since the Great East Japan Earthquake 2011 and remaining tasks in dust control.

Keywords: storage environment, mold, temperature, humidity, integrated pest management.

1. NDL's First Major Mold Infestation in FY2007

The National Diet Library is Japan's only depository library and carries the responsibility for passing on collected documents for future generations as valuable cultural properties. The NDL collection stacks are maintained at the Tokyo Main Library (the Main Building and the Annex), the Kaisai-kan in Kyoto prefecture, and the International Library of Children's Literature, and it was in Layer 14 of the stacks—each one-floor space is divided in two or three layers—of the Tokyo Main Library Main Building that mold infestation was discovered around mid-December 2007. In the main building, which was completed in 1968, stacks are housed in a 45-meter square cube occupying 17 layers above and below ground at the center of the building and surrounded by offices and reading rooms. Layer 14 is higher than the six-floor office part of the building. The NDL Annex building (completed in 1993) has offices on its aboveground floors and all eight floors of the stacks are below ground.

Diagram: Tokyo Main Building stacks



The mold was found among several thousand volumes of foreign books brought in around the 1970s, infesting alike leather-bound, vinyl-bound, paperback, and cloth-bound books. Data loggers were installed to measure temperature and humidity levels in the affected areas, but found that the levels were within the preset figures. The NDL had experienced some cases of small-scale insect infestation during the first decade of the 2000s, and it had recorded data and compiled and adopted a manual on how to deal with insect and microorganism damage, but this was the first time a large-scale infestation of mold had been found. Specialists outside the library were quickly consulted and measures taken upon their advice. The library was soon to be closed during the year-end and New Year holidays, so as a stopgap measure to prevent further spread of mold the Preservation Division staff wiped mainly the 700 or so most badly affected volumes with non-woven fabric cloths soaked with dehydrated ethanol.

When the library opened after the New Year 2008, the situation was reported to the whole NDL. Access to the areas most severely affected by the mold in Layer 14 was restricted, and in March 2008 (the last month of the fiscal year), a pest control company was engaged to clean the approximately 4,000 most badly affected items in an area a little less than half of

Layer 14, clean the stacks, and survey the environment. When a library user urgently needed a volume from the stacks in the restricted area before this work was performed, the Book Division staff members in charge of the area's management would retrieve the item and, if it showed signs of mold infestation, perform the cleaning treatment before it was handed over to the user. They received training from the Preservation Division on how to do the work.

2. Investigative Team from Eight Divisions: Anti-infestation Efforts in FY 2008

The results of the commissioned survey performed in March 2008 indicated that the mold that had adhered to the books had already died and that the air quality of the stacks was normal. The origin of the mold infestation was not identified, but the report indicated that it was likely that mold spores that had entered the stacks had spread because of conditions of temperature and humidity and nutrients favorable to its active growth.

In order to share awareness of the storage environment problem and conditions that needed to be dealt with, as well as consider necessary countermeasures, in June the Storage Environment Improvement Team[1] was formed of members from the eight sections related to the Main Building stacks. These eight sections were the Book Division (in charge of the materials that had been affected by the mold infestation), the Facilities Management Division that handles equipment and facilities including air conditioning, the Acquisitions Division which receives materials sent to the NDL, the Preservation Division in charge of the care of the collection, and the other divisions that have material stored in the Main Building stacks. In order to maintain a storage environment that would not be favorable to the growth of mold, the Storage Environment Improvement Team took the following measures while, whenever necessary, obtaining advice from outside specialists.

1) Monitoring of Stack Temperature and Humidity Levels and High Relative Humidity Countermeasures

Japan's June through September summer season is a period of high temperature and high relative humidity. The Tokyo Main Library air conditioning system operating from 9:00 a.m. to 7:00 p.m. maintained the temperature at 22°C with a relative humidity (RH) of 55%. Analysis of the summer 2007 data of the temperature and humidity sensors installed on the walls of Layer 14—the part that had suffered a major mold infestation toward the end of that year—revealed, however, that the relative humidity had risen on an average of nearly 70 percent from the latter half of July to the latter half of August. The location of the sensors that recorded the high RH levels did not necessarily correspond to the area where the most heavily affected mold infestation was observed, however, so at that time it was difficult to clearly attribute the mold infestation to high RH. During the summer of 2008, therefore, data loggers were set on shelves at about 30 locations on Layer 14 in order to record temperature and humidity fluctuations in as much detail as possible. The resulting figures showed that after the air condition was shut off, the RH rose to more than 65 percent, and in the upper part of some shelves the RH was higher than 70 percent. The RH of the areas where the mold infestation had occurred was higher than for areas where no infestation had been found.

The RH rose to over 65 percent for consecutive days starting in the latter half of July and mold was discovered in one place after another. So, as an affordable measure, one portable dehumidifier was installed in August and from mid-September the number was increased to

[1] Official name: Investigative Team to Improve the Storage Environment of the Main Building, Tokyo Main Library.

five, operated for 8 hours during the daytime. The temperature and humidity decreased following the increase in the number of dehumidifiers, but the decrease could also have been the result of seasonal change as well, so it could not be clearly attributed to the effect of the dehumidifiers alone.

2) Regular Inspection of the Affected Area

In order to locate and treat mold infestation as early as possible, between July and September we weekly made the rounds of the stacks in the badly infested areas on Layer 14 as well as the other layers where small amounts of mold had been found. Until around the middle of September, some dozens of cases of mold were found on each weekly inspection, and these book were treated by wiping with dehydrated ethanol. Such cases decreased sharply in the last 10 days of September as external air temperatures began to drop off, so from October, the inspections were carried out less frequently and terminated in areas where no new infestation was found. For fear of the effect of water on the materials, initially the books were cleaned with dehydrated ethanol, but from FY 2010 we have been cleaning them with ethanol for disinfection, which has stronger sterilizing power.

3) Cleaning of Books by Professionals

The cleaning of the 4,000 volumes of the most badly mold-infested area of Layer 14 was carried out in March by a professional company, but after a series of cases of mold were found during the summer, professionals were again hired to wipe the affected books, including those with a small amount of mold or dust, and clean the floors.

The Storage Environment Improvement Team confirmed that integrated pest management (IPM) was the basic policy of pest control for the NDL stacks. As you know, IPM is a methodology for pest control, using a combination of multiple reasonable means, as much as possible without relying on chemical pesticides. Before the team ended its activities at the end of FY2008 (March 2009), it organized the problems to be considered and issued a report of recommendations regarding the following two points.

• continuation of temperature and RH monitoring and countermeasures against high RH including the possibility of extending the hours of air conditioning operation
• establishment of a sustained, NDL-wide IPM system.

3. Establishment of an NDL-Wide Council for Environment Control: FY 2009

In response to the recommendations of the Storage Environment Improvement Team report, an NDL-wide Council on Storage Environment Information Sharing was established in August 2009 consisting of members of 17 divisions relating to the collection and the facilities in all NLD buildings (Tokyo Main Library, the Kansai-kan, and the International Library of Children's Literature). The Preservation Division served as the secretariat. The Council held meetings once or twice a year at which members reported on their storage environment activities, shared information, and discussed measures for further improving the library environment. The content of the Council's meetings was reported through regular executive meetings to the whole NDL, thereby informing all those working in the library, even if not directly related to the collection or facilities, about the IPM efforts. The Council met five times until 2012.

The Storage Environment Improvement Team recommendations had included consideration of 24-hour operation of the air conditioning as a means of dealing with high humidity, but the Council discussions concluded that 24-hour operation was difficult from a financial point of

view. It was decided instead to use a combination of feasible methods to combat mold infestation in the stacks throughout the NDL buildings. A number of countermeasures were studied and implemented that involved coordination by more than one division of the library. One measure was to have staff and outside visitors to the stack areas wear indoor-use footwear or put on shoe-covers in order to keep out dirt and dust that might provide a favorable culture for mold. Also, when newly acquired materials are introduced to the collection that might have been affected by pests, they are put through a disinfestation process before they are carried into the stacks.

A Mold Countermeasures Working Group was established under the Council to carry on the work of the previous year in studying the mold problem in the Main Building stacks and its countermeasures.

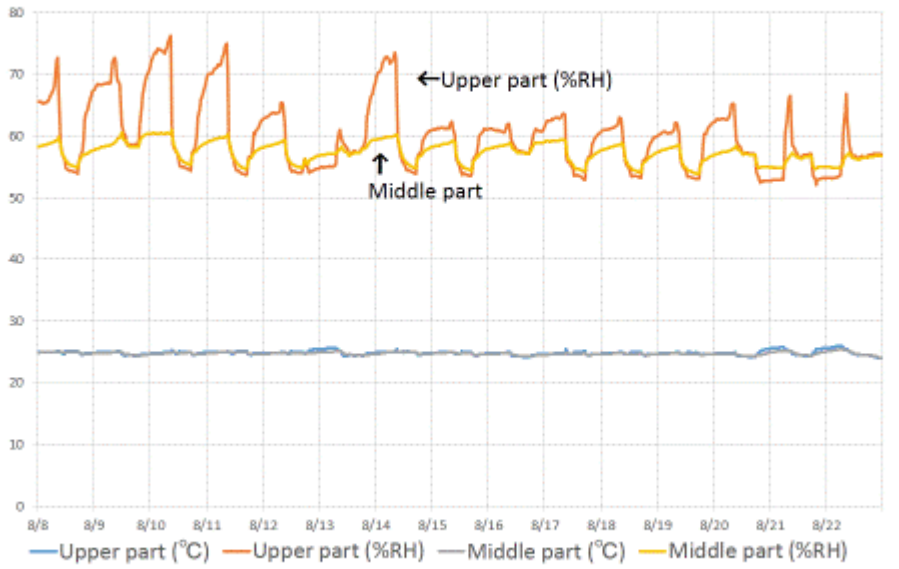
4. Working Group's Activities to Counter the Mold and High-Humidity Problem

The Working Group, which was made up of the staff members in charge from the Preservation, Facilities, and Book divisions, continued the practical activities implemented in 2008 by making regular rounds of the affected areas and wiping any books on which mold was detected, as well as coping with the problem of high relative humidity on the severely affected areas of Layer 14. The effect of all these various efforts was rewarded and although some dozens of book had been found every week to be infested with mold during the previous year, in FY 2009 and FY 2010, the total number of books infested was only around 200 volumes for the summer period (June through September). The number dropped off further to about 30 volumes in FY 2011, and leveling off to a figure of under that figure in subsequent years. The countermeasures carried out during the high temperature high humidity period each year were as follows.

2009

A temperature and humidity study of smaller scope than for the previous year was carried out. The nighttime high humidity conditions were found to be continuous, so in order to deal with the humidity increase, we tried operating portable dehumidifiers in the area between 5:00 p.m. and 9:00 a.m. The dehumidifiers collected full tanks of 5 liters of water every night and the humidity in the areas around the dehumidifiers was kept at as low as 50 percent. Also, when we increased the number of data loggers and conducted a survey to compare the upper and middle sections of shelves, we identified some differences in humidity between them. The "Upper part (%RH)" line in Graph A shows that during the nighttime after the air conditioning was turned off, the humidity of the upper parts of the shelves sharply rises. The humidity of the middle section also rises but the changes are less marked than for the upper section. It was thus determined that in the badly mold-infested area, air of high humidity was likely to collect in the shelves' upper parts, increasing the risk of mold infestation.

<Graph A> Humidity Difference: Upper and Middle Parts of the Shelves



Temperature and Relative Humidity in Layer 14, Area 3 from August 8 to 22, 2009

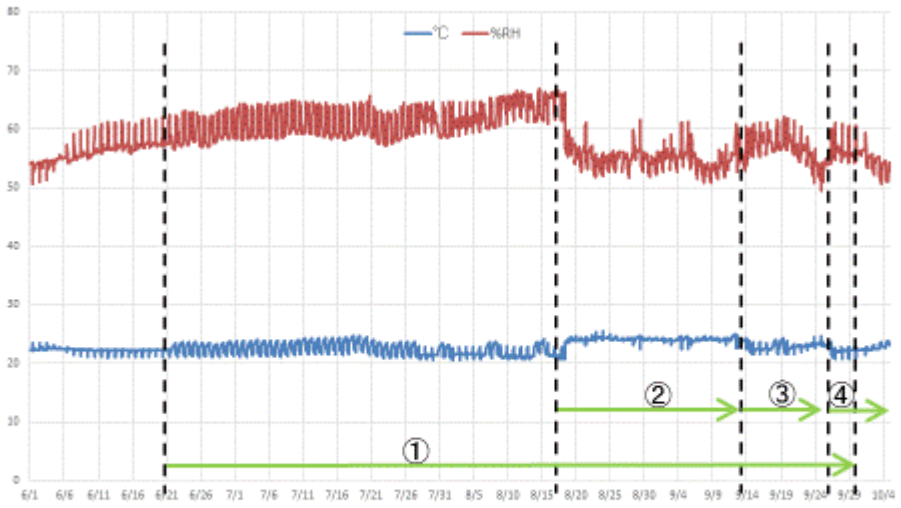
2010

The operation of the portable dehumidifiers was continued as during the previous year, but various problems remained to be solved: increase in humidity after the dehumidifier tanks are filled with collected water; difficulties in the disposal of the collected water; and danger of short-circuit or water-leakage accidents. On the other hand, temperature and humidity were measured only at the upper parts of the shelves, and it became possible to pinpoint where the high-humidity air collected. Then, the use of the air conditioning system to circulate air through the stacks during the night was tested, and this measure was observed to have the effect of preventing the increase of humidity in the upper section of the shelf.

2011

This year the portable dehumidifiers were not used and nighttime air circulation was the main measure used against high humidity. However, from the middle of August, the humidity began to steadily increase, so we tried a new strategy of increasing the set daytime temperature of the air conditioning from 22 to 24°C. This was an attempt to lowering the humidity by raising the temperature, and as shown in Graph B, this had the effect of lowering the humidity from near 65 percent to below 60 percent. By dispensing with the use of portable dehumidifiers, disposal of collected water was no longer a problem. This made it much easier to sustain humidity control operations.

<Graph B> Controlling Humidity by Adjusting Air Temperature



Temperature and Humidity in Layer 14, Area 3 from June 1 to October 4, 2011
① 6/21～9/30 Circulating Air at Night
② 8/18～ 22℃ ⇒ 24℃
③ 9/14～ 24℃ ⇒ 23℃
④ 9/26～ 23℃ ⇒ 22℃

2012 and onward
By circulating air during the nighttime and adjusting the temperature and humidity settings of the daytime air conditioning, we are now maintaining the RH of the problematic area to a level not higher than 65%.

5. Efforts to Decrease Hours of Air Conditioning

Now let me explain about the air conditioning of the stacks throughout the Tokyo Main Library. Following the Great East Japan Earthquake of March 2011 and the subsequent shortage of electricity in the wake of the nuclear power plant accident, the government called on the whole country to cut back electricity use by 15% during the summer months that year. The air conditioning at the NDL had been operated from 9:00 a.m. to 7:00 p.m. throughout the year, but in 2011, during the July-to-September period, it was turned off for most of the underground stacks except for the rare materials stacks and microfilm storage area. Air conditioning in the aboveground floors was operated, but a partial increase of the set temperature initiated by the above-described mold-infestation working group also contributed to power saving.

From October until the end of 2011, the air conditioning went back into operation, but during the January to March winter months, it was turned off as it had been during the summertime. The monitoring of the temperature and humidity conditions in the stacks was continued whether the air conditioning was in operation or not, and in particular areas, the air conditioning was turned on or air circulated partially, at the discretion of the Facilities Management and Preservation divisions.

From 2012 onward, there were no official electricity conservation requirements, but budget cuts meant that costs needed to be reduced wherever possible. Based on the constant monitoring of temperature and humidity of the stacks, therefore, the air conditioning or air circulation systems were turned on only in cases when the conditions seemed likely to suffer mold infestation or become excessively dry. Specifically, that meant adjustment of the

temperature and humidity when the temperature in the stacks exceeded 25°C or the RH exceeded 60% in the summertime and when the temperature and the RH fell below 19°C and 40%, respectively, in the wintertime. We also carefully record the temperature and humidity conditions using data loggers each time the air conditioning was turned on or the settings changed and, with skillful adjustment of the settings, no large-scale spread of mold has subsequently occurred.

The case of mold infestation and power-use restrictions following the March 11, 2011 earthquake were unfortunate events, but they prompted the NDL to more efficient use of its air conditioning through an accurate grasp of temperature and humidity conditions. In December 2013, the NDL held a Preservation Forum at which we introduced case studies of environment control in libraries and archives in Japan, heard lectures and recommendations by specialists in the field, and reported on the above-described efforts at the NDL.

6. Tasks for Library Environment Control

The study of the allowable scope for temperature and humidity from the point of view of collection care and the switch to a policy of minimal air conditioning based on careful monitoring of temperature and humidity have served to enhance the sustainability of NDL environment control. Prevention of insect and mold infestation only by temperature and humidity control based on a monitoring system throughout the NDL collections, however, is not feasible; measures such as preventing the causes of infestation from entering the stacks are indispensable.

The treatment of newly acquired materials to rid them of insects and mold before placement in the stacks had already been in practice. Monitoring of the dust that promotes mold and attracts insects, however, had not been thoroughly adopted. It is thought that increasing the number of times the stacks are regularly cleaned and limiting the number of visitors to the stacks may be effective steps, but it is difficult to numerically predict the effect of such measures. There are not established standards for the control of cleanliness in the stacks or for setting the allowable scope of cleanliness in a library, and this partly makes it difficult to pursue dust-control countermeasures. While awaiting advances in research in this field and more information useful for actual management of libraries, for the foreseeable future, we will continue to explore dust-control measures that can be done on a small-scale budget.