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Cold Storage of Photographs at the City of Vancouver Archives

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Introduction

The following is a case study of the efforts made at the City of Vancouver Archives to freeze its deteriorating photographic negative collections. We used two freezer packaging methods, both based on research done for the Smithsonian Institution[1]. The first was the Critical Moisture Indicator (CMI) method, in which a one-inch stack of sheet negatives was enclosed in a package which buffered humidity. These packages were boxed and frozen in a commercial frozen-food storage facility. The second method was the gasketed cabinet method. We were the first institution in the world to use this method, utilizing it before the research had been published. Information on the method was obtained from email correspondence with Mark McCormick-Goodhart who, with Henry Wilhelm, developed the method at Wilhelm Imaging Research, Inc., under contract to the Smithsonian Center for Materials Research and Education (SCRME).

Negatives packaged using the CMI method were frozen at first in a commercial cold-storage facility. Later, we were able to construct our own walk-in freezer, and moved the material there. Freezing using the gasketed cabinet method was done inside our walk-in.

One of reasons for the success of our freezing program is that it is being done in conjunction with a scanning program. So far, all the catalogued negatives which have been frozen have also been scanned at a high enough resolution that we can provide electronic access to the images and also provide prints up to 30" x 40". This reduces our need to retrieve images from frozen storage, and, since the longevity of the collections is decreased the more time the negatives spend outside of that storage[2], it benefits the negatives. The availability of scanned images made it easier to move the negatives to a remote commercial freezer from which retrieval would be difficult.

Details will be given on the procedures used for packaging, and considerations in the construction of a walk-in freezer. Reasoning behind the choices made will also be discussed. It is hoped that the methods used here will be of help to other small institutions who, by themselves or in a consortium, wish to find an affordable way to freeze large collections.

[1] The Critical Moisture Indicator method was developed by the Conservation Analytical Laboratory (CAL), which was renamed the Center for Materials Research and Education in 1998.

[2] James M. Reilly, *IPI Storage Guide for Acetate Film*, Image Permanence Institute, Rochester, N.Y7., 1993, page 8.

Our Predicament

The City of Vancouver Archives is a division of the City Clerk's Department of the City of Vancouver, British Columbia. Our operating budget largely covers salaries and building maintenance, with some funds for supplies. Our staffing consists of eight full-time positions, including one conservator, four archivists, reference and office staff.

Our photographic holdings contain about 1.5 million images, many of which are deteriorating negatives. We had been concerned since their acquisition about the welfare of two major photographic collections: the Williams Brothers Photographers Ltd. fonds, acquired in 1987, and Jack Lindsay Ltd. Photographers fonds, acquired in 1993. These collections are the life's work of professional photographers, spanning five decades; they arrived in twenty-seven filing cabinets containing about 200,000 images. They have important documentary value and they were certified by the Canadian Cultural Property Export Review Board as having national significance.

Figure 1. *Jack Lindsay Ltd. Photographers fonds, housed as received.*

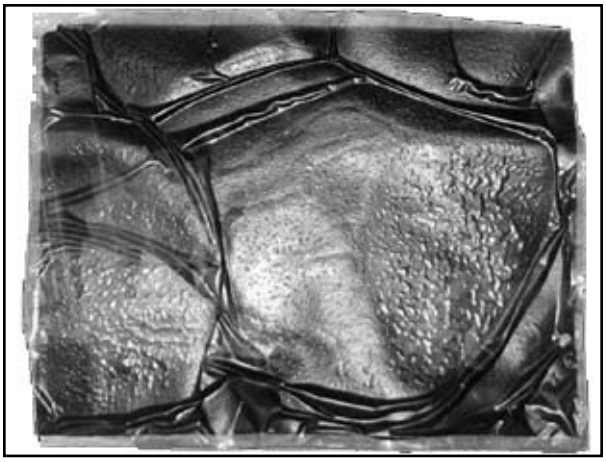

Figure 2. *Shrunken acetate. Our collection was quickly approaching this state.*

Unfortunately, the two collections are comprised of nitrate, acetate, and colour films, all of which are known to deteriorate in destructive and irreversible ways[3]. We were most immediately worried about the acetate negatives, the majority of the collection, because every time we opened the file drawers, there was a strong smell of vinegar which is a signal of degrading acetate. We knew that they needed low-temperature storage, but the methods available in the early 1990s were not affordable for us. We also knew that any solution should ideally benefit the hundreds of thousands of other nitrate, acetate and colour negatives currently in our collections, and those which would arrive in future acquisitions.

[3] James M. Reilly, *IPI Storage Guide for Acetate Film*, Image Permanence Institute, Rochester, N.Y., 1993, page 8.

While we pondered how to save these collections, we surveyed the acetate negatives twice—in 1995 and again in 1998—using A-D strips from the Image Permanence Institute[4]. From these surveys, we determined that many of the acetate negatives would be deteriorated to the point of being shrunken and brittle within a few years. Measurable deterioration had taken place in the three years between our surveys, and the most deteriorated negatives measured at Levels 2.0 and 2.5 on the A-D scale, meaning that they were actively degrading and had little time left before warping or channelling occurred. We had an immense problem, involving very important collections, and something had to be done quickly.

We considered our options.

1. Duplicate the negatives onto a stable film base.
This is a strategy that has been used for years in many preservation programs, including ours. Quality duplication, processed to archival standards, produces a film that, properly stored, will have a life expectancy of at least 500 years. Unfortunately, since we had 200,000 negatives to copy; at about $15 per copy, it was unaffordable, even if we only copied the 50% which were most vulnerable. Had we had decided to do this slowly over many years, it would have taken over 600 years if we had $5,000 per year to spend (which we did not). The copies of the coloured film would have started to fade as soon as they were created unless they were put into cold storage.

2. Cold storage at refrigerator temperatures.
Refrigerator-temperature storage was not going to preserve the negatives for very long; they needed to be frozen[5]. Freezing would slow down the chemical reactions that were producing the shrinkage of the acetate film, the loss of image of the nitrate film, and the fading of the dyes of the colour film. We reasoned that if we were going to raise money for a large project, we wanted to do it properly and create storage that would save our negatives for many years, as we might not get another chance for a long time.

3. Frozen storage in a temperature- and humidity-controlled environment.
When film is frozen, the relative humidity (R.H.) of its environment has to be controlled within a moderate range[6], as it does when the film is stored at room temperature. Keeping R.H. at a suitable level for photograph storage within a frozen environment is not simple. Large institutions, such as the National Archives of Canada, have purpose-built freezer vaults in which the humidity is controlled by a built-in dehumidification system. Although appropriate for an institution of that size, such a vault is more costly to build than a simple freezer, and requires an additional financial commitment to ongoing maintenance to keep it running properly. It also uses a lot of electricity, so operating costs would be significant.

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[4] A-D, or Acid-Detecting Strips measure the degree of deterioration in acetate film. They were developed by the Image Permanence Institute and are available for purchase from them. For more information, see the IPI Web site at http://www.rit.edu/~661www1/.

[5] Image Permanence Institute, *User's Guide for A-D Strips*, Version 1.6, Image Permanence Institute, Rochester, N.Y., 1998, page 8.

[6] James M. Reilly, *Storage Guide for Color Photographic Materials*, University of the State of New York, New York State Education Department, New York State Library, the New York State Program for the Conservation and Preservation of Library Research Materials, 1998, page 38

Such a vault would have to be purchased—no facility of this kind was available for rent—and all the associated costs were beyond our means.

4. Frozen storage of heat-sealed packages.
In this storage method, small stacks of negatives are sealed within packages fabricated from a sheet made of laminated layers, with paper on the outside, polyethylene on the inside and metal foil in between[7]. The foil acts as a vapour barrier, the polyethylene allows the package to be heat sealed, and the paper further protects the foil and gives a surface for labelling. This was considered carefully, but because of several costs and uncertainties it was rejected. There would be no way of knowing if the packages were fully sealed without weighing each one to detect ongoing weight increases. If there were any pinholes or other imperfections in the foil, or if the heat seal had gaps, moisture would be allowed into the package and we would never know it. The packaging material is fairly expensive—to store all 200,000 negatives would have cost $50,000-60,000—and once they have been heat sealed, the end has to be cut off for access, limiting reuse.

5. Frozen storage in packages which control humidity by trapping incoming moisture.
In the late 1990s, research at SCRME. produced a storage method which controlled the R.H. within individual packages rather than within the freezer, allowing negatives to be stored in a conventional freezer. The packages were resealable, so they could be reused when negatives were retrieved from frozen storage. Each package contained a humidity indicator to show when the R.H. was approaching an unacceptable level. It was called the Critical Moisture Indicator method, and it seemed to us to be the best combination of economy and caution for our collections.

We decided to use #5, the Critical Moisture Indicator method, on 113,000 of the most rapidly deteriorating negatives in the two collections. We received a Preservation Management grant from the Canadian Council of Archives which partly covered the cost of materials. As we did not have a freezer, we intended to freeze the negatives off site at a commercial cold storage facility until we could build our own.

[7] One brand is Vapour Seal, available from Light Impressions.

Critical Moisture Indicator (CMI) Method[8]

Packaging Materials

The CMI method was intended for use with smaller collections. One company, Metal Edge, manufactures storage kits[9] using this method, but there were two problems with our using the kits. First, the cost was more than we could afford; it would be cheaper to assemble kits ourselves. Second, the kits only came in one size, flat boxes 13" x 10" x 1.5", designed to hold slide pages. We needed to package several different film formats, and it would be easier to buy the materials and customize them. We had to come up with a way to scale this method up to house 113,000 negatives safely and cheaply.

We did not need to look far for packaging ideas. Betty Walsh, of the British Columbia Archives, had already adapted the CMI method for use with 4" x 5" negatives, packaging a few thousand at a time, and storing them in upright (household) freezers. She generously supplied us with diagrams and specifications. We used her method, but adapted it to make it cheaper, as we needed to house many more images immediately.

Essentially, the CMI method works as follows. About an inch of sleeved negatives are sealed inside a zip-closure polyethylene bag. Two pieces of dried 4-ply mat board, a pink/blue humidity indicator square[10] and the bagged negatives are put inside a second zip-closure bag.

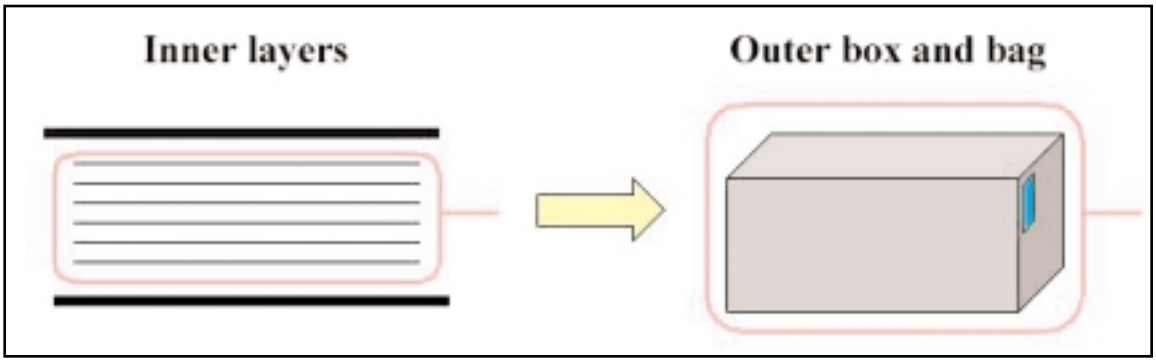

Figure 3. *Basic Critical Moisture Indicator package construction.*

The two layers of mat board provide passive humidity buffering; any water vapour permeating the package will be absorbed by the dry mat board. The humidity indicator will begin to change colour before the humidity in the outer layer of the package becomes too high, and then the package will be opened and the exhausted mat board

[8] Mark H. McCormick-Goodhart, "On the Cold Storage of Photographic Materials in a Conventional Freezer Using the Critical Moisture Indicator Method", unpublished manuscript, available from the author in PDF format. Email: mccgresearch@aol.com. Anyone contemplating using this method should read this paper.

[9] SafeCare Image Archive Freezer Kit, available from Metal Edge. It consists of two precut mat boards, two polyethylene bags and one box affixed with humidity indicators.

[10] Self-adhesive cobalt chloride humidity indicator squares, HIC60ADH, from James Dawson Enterprises Ltd.; indicates 60% RH at 25°C by a lavender colour, below that value it is blue, and above that value it is pink. The colour change is gradual, through a range of shades.

will be replaced with freshly-dried board. The negatives will always remain sealed in their inner package unless they are required for research. The exhausted board will be re-dried and reused in another package.

The longevity of this method, measured in the time that will elapse before the mat board needs to be changed, depends on many factors which affect how quickly water vapour will penetrate the package and how much will be absorbed by the mat board. Some of these factors are:

- quality of the mat board. A less-dense board, or one with a lot of non-absorbent filler, would have less fibrous material to act as a moisture trap.
- dryness of the mat board. The drier the board, the more capacity it has for absorption.
- thickness of the plastic in the bags. Polyethylene is not a complete vapour barrier, despite its being labelled as such in house construction. Water vapour will move through it slowly at room temperature and especially slowly at freezer temperatures. Thicker bags slow the transmission even further.
- seal on the plastic bags. A reliable zip seal will not contain any holes.
- construction of the plastic bags. Cheap bags might have holes in the seams.
- fit of the plastic bags to their contents. The larger the bag, the larger the surface area available to transmit water vapour. A bag that is much large than necessary will reduce the longevity of the package.
- temperature of storage. Colder storage temperatures slow down the rate of water vapour transmission through the plastic.

To adapt this method for 4" x 5" format negatives, the B.C. Archives used zip-closure freezer bags from a grocery store, Rising Museum Mounting Board[11] as the mat board, an inner jacket (for support and labelling) made from map folder stock, a moisture indicator square on each 1" package, and filed the packages upright in corrugated plastic[12] boxes. This method was well-suited for their application but had some disadvantages when scaled up to the quantities we needed to house. The boxes would have to be opened in order to check on the status of the moisture indicator, as the indicators were only present on the 4" x 5" packages within the box. The plastic boxes were an excellent choice: sturdy, chemically safe for photograph storage, and unaffected by moisture. They were also far too expensive for our budget.

We considered using Ziploc-brand freezer bags purchased in bulk from Costco, but instead we purchased from an American supplier[13] who had much thicker bags, in a variety of sizes, at a better price for the quantity we required. These bags had been used in the research for the CMI method[14], so we knew that the quality of the seal would be good. In fact, it was so good that the bags were difficult to open at first.

[11] Available from framing suppliers.

[12] Available from Envimaco. Item #45GPN, sold as storage boxes for glass plate negatives.

[13] International Plastics, stock 4 mil polyethylene zip-closure bags, 8" x 8", 12" x 12" and 13" x 18". Larger bags (14" x 24", 30" x 30") were unavailable with zip closures and were sealed with tape.

[14] McCormick-Goodhart, "On the Cold Storage . . .", page 13.

We used Rising Museum Mounting Board as our mat board in the inside packages. We did not want to compromise on the quality of materials within the packages.

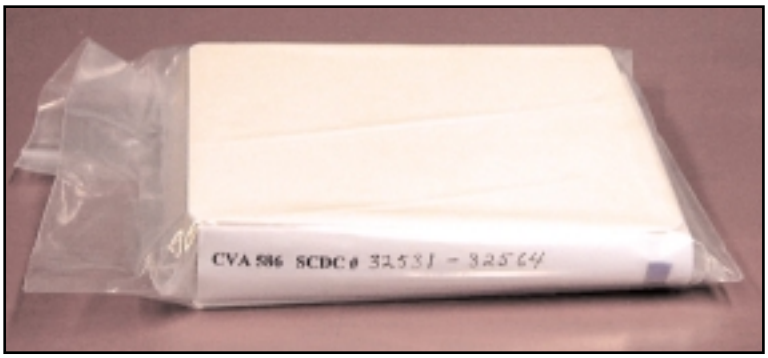

Figure 4. *Inner package used by Vancouver Archives.*

For the inner jacket, we decided against using map folder stock because it was too expensive and we expected the two pieces of 4-ply mat board to supply enough physical support for the package. The jacket is not part of the moisture trap, so it is optional[15] but useful for labelling. We decided to use photocopy paper for our labelling. A half sheet was used for the smaller packages, and a full sheet for the larger ones; it was important to make the labels large enough that they could be wrapped around the packages, reducing the likelihood that they would shift in the package and render the label unreadable. The paper could be partly prepared in advance with the repetitive part of the labels (collection name and number) on the photocopier, saving writing.

For the boxes, we used custom-cut boxes made from ordinary (not archival) corrugated cardboard. We could specify the dimensions we required, so we could make sure that they would be large enough to contain the somewhat bulky inner packages. We purchased the bags first, then made mock-ups of the inner packages, and made specifications of the boxes from these. It is not generally recommended that photographic materials be stored in such low-quality packaging, but we made this compromise because the negatives are double bagged inside these boxes, so there would be very little transfer of pollutants from the boxes to the negatives. As well, the entire system would be frozen, further inhibiting transfer. Finally, it was intended that these negatives would, within decades, be moved into gasketed cabinet storage and not be stored in these boxes indefinitely.

These cardboard boxes were not resistant to moisture, so they were enclosed within a third plastic bag[16]. The bags are inexpensive, so the additional cost was minimal, and still far less than the cost of the plastic boxes. This also solved another problem. We put a humidity indicator square on the end of the box and two large pieces of dried mat board[17] outside the box before we enclosed it in the outermost bag. This allowed us to have an easy way to check on the humidity status of the boxes without opening them. As the boxes sat on the shelves in the freezer, we could quickly glance at all the indicator squares to be sure they were still blue and all was well. As a bonus, it also gave us an extra moisture trap (the outer mat board) and an extra layer of plastic to protect the inner packages from moisture transmission.

[15] McCormick-Goodhart, "On the Cold Storage . . .", page 2.

[16] Zip-style closures were not available for stock bags in this size so we purchased unsealed bags and closed them with freezer tape.

[17] Needing to save money, we used a cheaper product, 'flawboard', a mat board which has been damaged or suffered a manufacturing error which produces a visual flaw. It is also acidic but is being used outside an acidic box.

We also had to house 5" x 7" and 8" x 10" format negatives. The inner packages were constructed in the same fashion as for the 4" x 5" negatives. We used standard 12" x 12" x 15" records boxes, which fit 8" x 10" negatives in one row across, and 5" x 7" negatives in two rows.

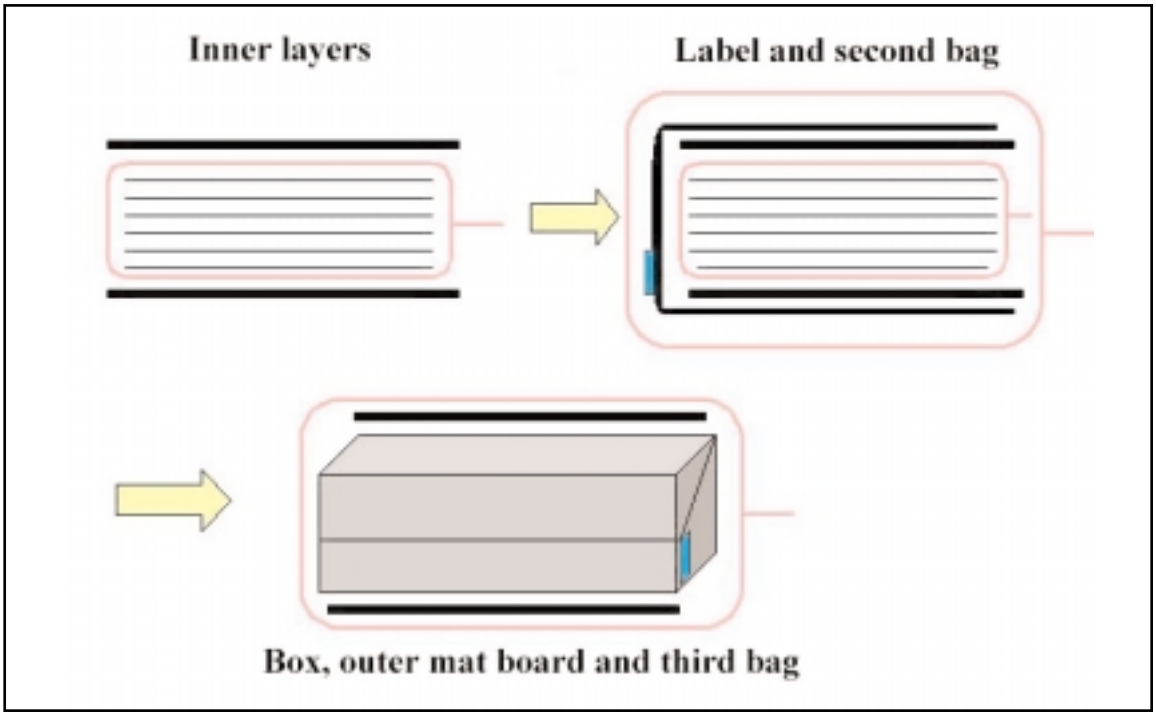

Figure 5. *Adaptation to CMI packaging used at Vancouver Archives.*

Preparing the Mat Board

We needed several thousand cut pieces of mat board, so they were prepared in bulk. The pieces were cut on board shears with a 40" blade, but it was still exhausting work. A heavy ski glove was worn to cushion the hand operating the blade, and many breaks were taken. The corners of the cut pieces were rounded so that they would not puncture the plastic bags[18]. The most efficient way to do this was to use a disc sander[19] to round the corners of stacks of fifty boards. This took a few days. Goggles and a dust mask were necessary.

Next, these boards had to be dried in an oven. The method described in the research paper is to "place the mat board in a standard convection oven for 3-5 minutes at 100°C"[20]. The boards need to be dried as fully as possible, and all surfaces must be exposed in the oven so that they can dry evenly without curling. The boards are removed from the oven,

[18] McCormick-Goodhart, "On the Cold Storage . . .", page 9.

[19] Courtesy of the Display Department, Vancouver Museum.

[20] McCormick-Goodhart, "On the Cold Storage . . .", page 4.

allowed to cool to room temperature (during which time they may continue to lose moisture, not gain it as one might expect) and immediately used or sealed in a plastic bag for later use.

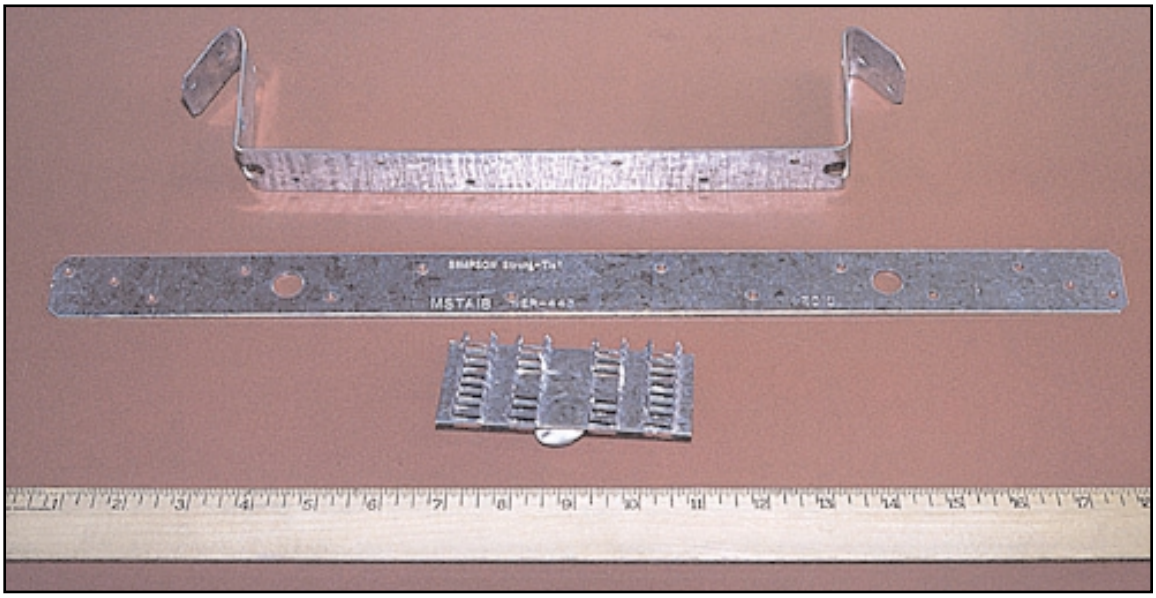

Figure 6. *Parts for 'toast rack' mat board drying apparatus. Top: Strap tie bent to form handles. Centre: Strap tie, as purchased. Bottom: Deck mending plate. Wooden rulers were used to lift the hot racks.*

Figure 7. *Bottom: Toast rack assembled. Top: Loaded with mat boards.*

We had two toaster ovens and a laboratory oven[21] available. Laying the mat board flat on multiple oven racks would allow about 20 pieces to be dried at once, and we had several thousand boards to dry. We made a 'toast rack' out of deck mending plates and strap ties adhered with 2-part steel epoxy[22]. The strap ties were bent to form handles and to provide a surface for adhering the mending plates. The mending plates have short spikes sticking up from the bottom which were long enough to support cut mat boards placed between them. They allowed all the surfaces of the board (except a portion of the bottom edge) to be exposed while in the oven. Several of these were fabricated so that the ovens could be fully loaded with racks. Larger plates and straps were used to make racks for the larger pieces of board. Using this system, 150-200 boards could be dried at once.

We had to determine how much more drying time would be necessary when the ovens were loaded with this much board. We tried to find a moisture content meter which would give us a direct reading of the moisture content of the dried boards. Low initial moisture content (MC) is important for the longevity of the package. An MC of 0% was predicted to give a package shelf life of 19 years, while 4% would give a shelf life of only 9 years[23]. Unfortunately, these meters are expensive, and the only ones available for loan were made for testing wood. The measurements were taken with large spikes unsuitable for small pieces of board, and they were not accurate below 5% MC, the range of interest. The boards could be weighed, and the weight graphed against drying time to determine an endpoint, but we did not have an analytical balance so the measurements would not be useful. Cobaltous chloride humidity indicator cards[24] were suggested[25] as a way of monitoring stored pre-dried boards to ensure they had stayed dry. The lowest indicator on these cards is usually 10% R.H.; if that square stayed blue, then the boards would be dry enough to use. The boards were dried for a period of time, cooled slightly and sealed inside a zip-closure bag with a cobaltous chloride indicator card. This was continued until all the squares on the card turned blue. A two-cubic-foot laboratory oven full of racks of board took about an hour to dry the board. As a double-check, a Vaisala R.H. meter[26] was enclosed in a bag full bag of dried mat board overnight. It read 1.2% R.H., which indicated the board was very dry.

Packaging the Negatives

Once the board was dried and double-bagged for storage, the packages were created. We were fortunate to be able to do this in a well-ventilated darkroom to avoid irritation from the acid vapours given off by the negatives[27]. The negatives were acclimatised to the 50% ambient R.H within our storage; negatives should not be packed if they are

[21] Courtesy of the Conservation Department, Vancouver Museum.

[22] All available from hardware stores.

[23] McCormick-Goodhart, "On the Cold Storage . . .", page 12.

[24] Blue-lavender-pink indicating. Available from archival suppliers, including Carr McLean and University Products.

[25] McCormick-Goodhart, "On the Cold Storage . . .", page 4.

[26] Courtesy of the Conservation Department, Vancouver Museum.

[27] David G. Horvath, The Acetate Negative Survey: Final Report. University of Louisville, Ekstrom Library, Photographic Archives, Louisville, KY 40292. February 1987. page 61.

Figure 8. *Loading the boxes.*

acclimatised to an RH outside the range of 35-60% at 25°C[28]. A group of negatives no more than one inch thick was taken from its original box, the numbers and packing date were written on the prepared photocopied label with a Pigma pen[29], and an indicator square was adhered to the label. The negatives were inserted into the first bag, the excess air squeezed out, and sealed. Two dried boards were quickly removed from their storage bag and placed on either side of the inner bag. The paper label was wrapped around the mat boards, everything was put into the second bag, the excess air was exhausted, and it was zipped shut. The package was placed into the cardboard box, and this was repeated until the box was full. Box contents were recorded for later reference. Larger pieces of dried mat board were placed on either side of the box and everything was enclosed in the third bag, which was folded neatly at the open end. The bag was sealed with freezer tape[30] by wrapping the tape around the box so that it adhered to itself, as it did not adhere to the polyethylene bag satisfactorily. It was suggested that 3M Scotchbrand #850, 1" wide could be an alternative[31] sealing tape.

Deteriorating negatives should not be kept sealed in plastic at room temperature for long. We needed to store the negatives frozen until they could all be transported to the commercial freezer facility as one pallet load. The boxes were stored in a small walk-in freezer (at -9°C) nearby[32] and in an old household chest freezer which had been donated. Packaging took many weeks.

[28] Mark H. McCormick-Goodhart, "The Allowable Temperature and Relative Humidity Range for the Safe Use and Storage of PhotographicMaterials", *Journal of the Society of Archivists*, Vol. 17, No. 1, 1996, page 11.

[29] Available from art and stationery stores.

[30] Available from grocery stores. The adhesion of the tape to the polyethylene bag was inadequate, so, to ensure the bag would stay sealed, the tape was wrapped around the boxes back onto itself.

[31] Email communication, Mark McCormick-Goodhart, December 21, 1998.

[32] Courtesy of the Vancouver Museum.

Freezing in a Commercial Facility

Selecting the Type of Freezer

Before we made final our plans to freeze using the CMI method, we had to determine where the material would be frozen. We considered several alternatives, including the purchase of a small household or commercial freezer. It was not as simple as looking at the cubic footage of the freezer and the price, and calculating a price per cubic foot, because different configurations of freezers result in different space utilizations. For instance, reach-in freezers (such as home freezers) have a shelf space utilization factor of 80%, meaning about 20% of the volume of the shelf is unavoidably unused. Walk-in freezers have a 33% volume utilisation factor, which means that about 33% of the volume is taken up with storage furniture such as cabinets and shelving (50% if compact shelving is used), and the rest is used for clearance space above and around the storage units, and aisles[33]. They do have an 85% shelf space utilisation factor. Reach-in units are more expensive to operate in terms of energy costs, and, when multiple units are used, each door requires floor space to allow room for opening.

Both types of freezers may be used for the CMI method; only the walk-in is useable with the gasketed cabinet method. We decided that, given the total size of our collections which would need freezing in the future, we would plan to purchase our own walk-in freezer at some time in the future. In the meantime, we would palletise the negatives and freeze them off site in a commercial cold storage facility, paying monthly storage fees.

Finding a Suitable Commercial Facility

We were concerned about the suitability of these facilities for handling negatives. We were looking for a space with moderately cold temperatures; extreme cold (-28°C) was unnecessary for our purposes and would make the negatives very brittle and more likely to shatter and chip. Staff needed to understand that this was delicate material and be willing to treat it carefully.

We spoke to many local commercial freezing operations to discuss the possibility of housing our collections there, and visited to speak to the staff. Some facilities were counted out because the staff said they would have to stack a pallet onto ours, and we did not want anything crushing our negatives. One facility seemed to have competent staff, but the unfrozen staging area, the area in which we would have to load and retrieve items from the pallets, smelled like fish and was all wet.

The facility we chose had interested, helpful staff, including management, and also happened to be the least expensive because it was an hour's drive away on the highway. It only took in frozen food, never fresh, so the facility was clean and odour-free. They were happy to discuss any possible hazards that our collections might face. They admitted that on rare occasions one of the lines would break and spray ammonia in the storage area, but that it was very localised and always repaired immediately. Our negatives would be packaged in so many layers on top of the CMI packaging that we thought the

[33] McCormick-Goodhart, "On the Cold Storage . . .", Figure 9.

Figure 9. *Unloading the boxes.*

risk of ammonia damage would be small. They said that their temperature controls rarely broke down, and were repaired right away.

We were not intending to retrieve any negatives while they were stored off site, but if it was necessary, we would have to pay to have the pallet retrieved and returned to the shelf. There is also a charge for renting the pallet. The staff agreed to place our pallet in the very back in a corner where it would never have to be moved to get at any other pallet. All the other pallets in storage contained frozen foods which were there for a short time, but ours was in deep storage, and needed to stay put.

The City wrote a standard contract to purchase services, with the facility being liable for damage or loss. There was an initial charge for putting the material in storage and monthly charge calculated per pallet. The facility was purchased by a larger company while our materials were there, and they imposed a minimum monthly charge. We had one pallet in storage, they wanted us to pay for four. We left the negatives in place and increased the payments.

Transporting and Palletising the Collections

The collections were removed from their temporary storage in our chest freezer and Vancouver Museum's walk-in freezer and allowed to warm up for a few hours before transport. We did this to reduce the risk of breakage from the cold, brittle collections vibrating in the van. The only vehicle available to us was a small City van. We padded the cargo area with many layers of large bubble wrap, loaded the boxes, and stuffed enough bubble wrap around and over the boxes to keep them from sliding.

Once we arrived at the commercial facility, we covered the bottom of the pallet with a precut piece of corrugated plastic to provide more even support, then loaded the boxes on. We had already test-stacked them at the Archives to make sure we had one full pallet load, and to ensure that we knew how to arrange them so that they would fit on a pallet. We had been told the pallets were 4' square, but these are nominal dimensions; when we insisted, the staff measured one and discovered they were actually 48" x 40", and we planned accordingly. The boxes were narrow and sturdy, and there was enough clearance between the top of the negatives and the inside of the box lid that we assumed they could be stacked without crushing the contents.

After the boxes were arranged on the pallet, we covered the five exposed sides with precut corrugated plastic sheets, and taped them together with duct tape. The plastic was there to protect the boxes from any small nicks they might receive as they were

Figure 10. *Boxes stacked on pallet.*

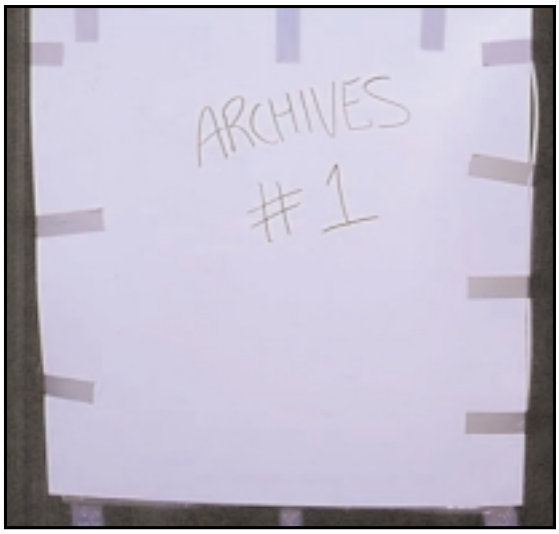

Figure 11. *Pallet covered in Coroplast.*

being lifted on and off the warehouse shelf. We did not want the outer plastic bags around the boxes to be compromised by cuts or tears.

The boxes were stored in this facility from June 2000 until February 2002. We requested that the pallet be removed from frozen storage sixteen hours before we returned with the truck to bring them back, in order to allow them to warm to a less-brittle state. The boxes were put immediately into our walk-in freezer upon their return to the Archives. The humidity indicators remained blue throughout this procedure, and, one year later, are still blue. Negatives retrieved since have appeared sound.

Walk-in Freezer

Planning the Freezer

Off-site storage was always intended to be a temporary measure. We wanted to build our own freezer, but the acetate[34] negatives did not have time to wait for us to build it—they were degrading too quickly. Once they were safely frozen, we could commence planning our own facility.

All the staff at the City of Vancouver Archives were in favour of finding a way to build our own freezer, considering it our top long-term goal. The Friends of the Vancouver Archives were convinced that the need was urgent and wanted to support the project. Fortunately, they were able to get a provincial grant to cover the purchase of the freezer, and we would pay for its installation.

We knew that Mark McCormick-Goodhart was researching a way to store larger collections in walk-in freezers using cabinets. The research was successful and not yet published, but he generously gave us information about the new system which helped in planning the freezer. With the name of the company that manufactured the cabinets, and knowing that we had to leave six inches of clearance around the outside of the cabinets and one foot clearance on top, we were able to plan the inside dimensions of the freezer so that the cabinets would fit. We also had to make sure that the clearance was enough to allow the cabinets to be carried into the freezer sideways, then swung in an arc to the upright position.

We had previously estimated what volume of our current holdings would benefit from frozen storage, so we had an idea of the minimum size we hoped to build[35]. The freezer was limited in size by our budget and by the plan of the room in which it would be built, which contained large support pillars. The freezer needed to be built next to two walls, and contractors recommended a two-inch gap between the room walls and the outside freezer walls. The room had overhead electrical raceways and piping which could only be moved at great expense, so they were left in place, but the long bolts supporting the raceways were replaced with a more compact support system to allow a few extra inches in freezer height. Before installation, a room light switch which would have been hidden by the freezer was moved to another wall. We had to be sure there was access to a drain for water condensate. A floor drain would be adequate, but we ran copper piping to a sink drain in the next room, as it was closer.

As a further complication, the space was shared with another institution, which used it as a work room, so the freezer had to operate quietly. Finding a compressor that was quiet enough in our price range was not possible, so we paid extra to run our lines onto the roof, where the compressor was secured in a pre-existing metal ventilation cage. The only noise the freezer now generates in the room is from the air circulation fan

[34] For freezing large collections of nitrate negatives, consult local fire codes.

[35] Thanks to Tania Passafiume for her extensive calculations.

inside, which is faint, and from a small drainage pump which runs occasionally. The disadvantage is that the piping for the refrigerant runs through our archival storage area, but there were already pipes for steam and water running along the ceiling in that space.

Building the Freezer

The freezer would be custom built from pre-manufactured insulated panels with metal skins. It would be auto-defrost, with large fans for air circulation inside the freezer. The freezer would have roughly 15' x 15' x 8' exterior dimensions, or about 1,600 cubic feet inside. It would be the same as freezers sold for restaurant use, with a few modifications, so bids were sought from firms which installed such units for the restaurant industry. It was preferred that the same company would sell and build the freezer, and install the compressor and pump, so that one company was responsible for the entire system should any problems arise, without any subcontractors involved.

These are the features we decided to request, and why:

- larger door. A standard door is 36" wide. We decided that it would be much easier to get large quantities of materials, as well as shelving and cabinets through a 42" door. Doors are available in still larger sizes. Larger doors are more expensive because they need extra reinforcement and stronger hinges. Spring loaded doors move more easily.
- lockable door. Our freezer is in a space shared with another institution and security is a concern. It also keeps the curious from opening the door just to peek. The door also comes with a safety release handle which will open the door from the inside even when locked.
- heated door frame. This keeps the area between the door and its frame fairly clear of frost so that a good seal may be maintained.
- vapour-proof interior lighting. We have one 100-watt incandescent bulb near the door, which seems sufficient, although it casts shadows on the far side of our tall shelving, and we usually bring a flashlight for best visibility. Fluorescent lighting, or ceiling lights are available from some manufacturers and might be preferable.
- external light switch. It comes with an indicator light which shows if the light has been left on.
- three-inch thick wall panels filled with polyurethane foam. Vendors would quote the thickness of the walls, but not always name the type of insulation. Three inches of polyurethane foam has, depending on density, an initial R value equal to or greater than four inches of expanded polystyrene. Results of testing commissioned by makers of extruded polystyrene[36], released after our freezer purchase, suggest that extruded polystyrene might be the best choice for restaurant freezer applications. Restaurant industry use involves frequent daily access, unlike archival storage applications, so their results may not be relevant.

[36] Scientific Data Disproves Insulation Misconceptions, accessed February 8, 2003, http://www.uscooler.com/news/Insulation_Tech_Release062802.htm.

- single phase compressor. The choice was single- or three-phase, and our freezer was small enough that a single-phase was all that was required.
- digital temperature control. We had read[37] that it was worthwhile to pay extra for a digital temperature control because it was better at holding a steady temperature.
- interior circulation fans interlocked with the compressor[38]. This causes the fans to turn off when the compressor turns off. In a standard restaurant freezer, the fans run continuously to keep the humidity higher to prevent freezer burn. We would like the humidity inside our freezer to be as low as possible. (This is not done in restaurant installations, and may cause some contractors to object.)
- automatic defrost. We set ours to run three times daily.
- temperature alarm. The normal operating temperature of our freezer is -18°C. The alarm limits are -25°C and -14°C, chosen so that the defrost cycle, in which the temperature will rise by a few degrees, will not induce the alarm to sound. The alarm will sound one hour after these limits have been reached, giving the freezer time to reduce its temperature to within these limits after the door has been opened for loading. The alarm has a battery back-up if the power should go off.
- taped seams. The contractor caulked all seams with silicone, as with any usual installation. It was recommended[39] that the seams be sealed on the outside with metal tape[40] as another moisture barrier. Unfortunately, since our freezer was constructed in a corner against two walls, it was not possible to seal the seams next to the walls. (Taped seams are not standard for restaurant installation, but we did not hear any objections from contractors.)
- air-cooled compressor. The City of Vancouver favours air cooling because water cooling wastes water.

Building the freezer took place over several days. We had a level concrete floor on which to build, so no expensive preparation was necessary. The entire room was cleared to allow space for the panels to be laid out and manoeuvred into place. When it was time to solder piping, the contractors duct-taped a plastic jug over our smoke detectors to prevent the alarm from sounding, a standard precaution. When the fire truck arrived, the firefighters advised us that our smoke detectors were much more sensitive than those commonly used in the restaurant industry, and that the taping of the jug would have to be *completely* airtight to avoid setting off the alarm.

The freezer was completed mid-December 2001, and was allowed to run empty until the end of January 2002 to be sure that it was running properly. Two double-depth bays (42" x 88" x 30") of ordinary records shelving were constructed and moved inside, with

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[37] Mark H. McCormick-Goodhart, *The Cold Storage of Photographic Collections Using Conventional Freezer Storage*, Adobe Acrobat version of presentation given at the 14th Annual National Archives and Record Administration Preservation Conference: Alternative Archival Facilities, held at the National Archives in Washington, D.C on March 25, 1999. Accessed February 7, 2003. http://www.wilhelm-research.com/pdf/nat_archives_99.pdf, page 12.

[38] McCormick-Goodhart, *The Cold Storage of Photographic Collections*, pages 13, 14.

[39] Email communication with Mark McCormick-Goodhart, May 14, 2001.

[40] Available from hardware stores.

Figure 12. *Freezer sharing work space.*

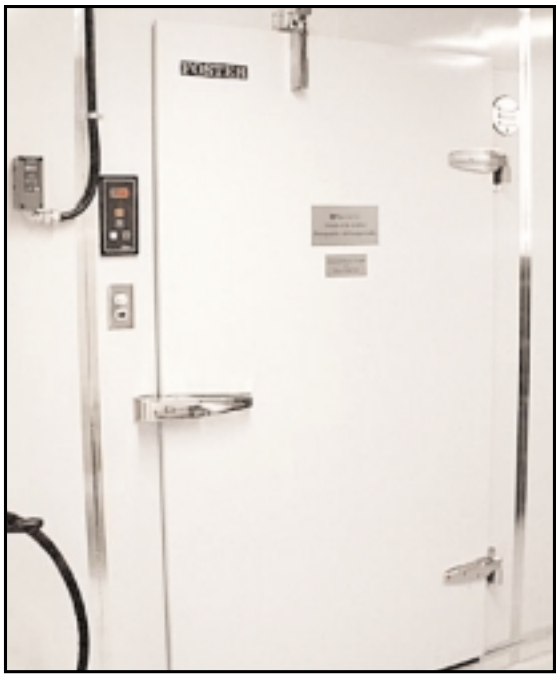

Figure 13. *Freezer showing taped seams, alarm panel (read light).*

plastic covers slipped on the bottom of the angle iron to prevent scratching of the freezer floor and to help distribute the weight loading more evenly. The negatives stored in the commercial facility were moved into our freezer in early February 2002, and filled about two- and one-half bays.

The total cost for the freezer and installation was about $25,000. The shelving was obtained for free from another City division which was moving.

Publicity

Since the freezing project was one of the largest single projects ever accomplished by our archives, we thought it deserved recognition, so we organized some inexpensive publicity surrounding the official opening on February 20, 2002. We created a small exhibit in our lobby which explained the project, and duplicated this as a virtual exhibit on our web site[41].

Figure 14. *CMI-packaged negatives in our walk-in freezer.*

[41] Sue Bigelow, Friends of the Archives Cold Storage Facility, July 9, 2002, February 7, 2003. http://www.city.vancouver.bc.ca/ctyclerk/archives/about/freezer.htm.

A plaque was affixed to the door of the freezer, proclaiming it to be the "Friends of the Archives Photographic Cold Storage Facility". Mayor Philip Owen agreed to cut the ribbon, which ensured that newspapers and television stations were interested in our press release[42]. We prepared a fact sheet for the press[43] and were pleased at the accuracy of the coverage.

We held a modest reception at which we served a cake decorated with an icing replica of one of the frozen photographs.

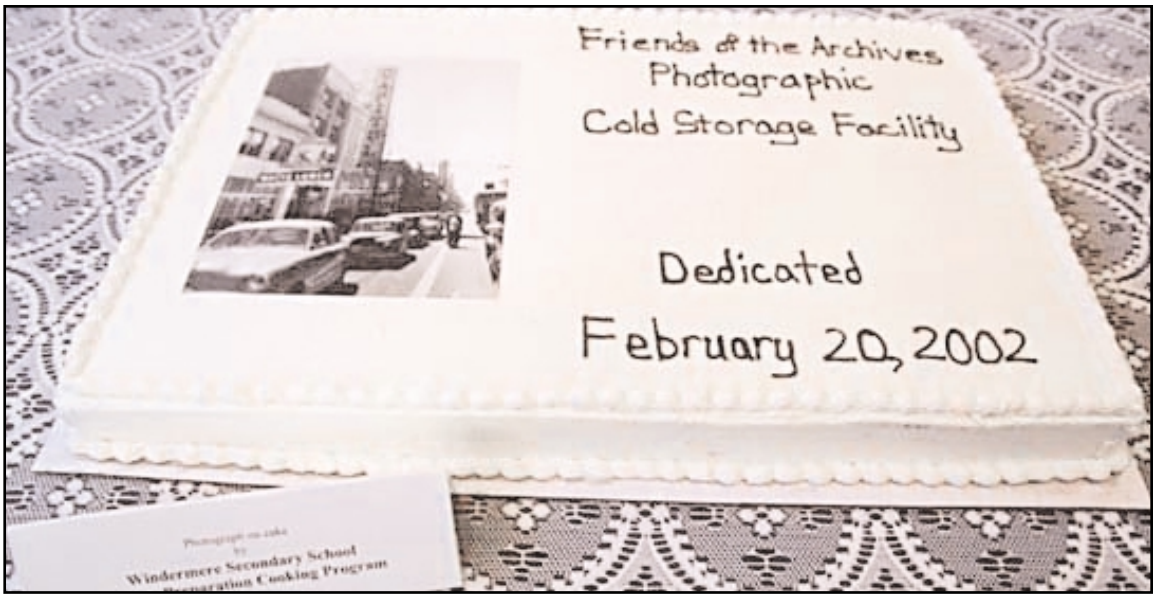

Figure 15. *The cake.*

[42] See Appendix III.

[43] See Appendix IV.

Gasketed Cabinet Method

Introduction

In this method, the negatives are stored inside a well-sealed cabinet within a walk-in freezer. No additional repackaging is required: the negatives may be stored in their regular archival envelopes and boxes. Boxes of negatives are transferred in and out of the cabinet in an acclimatization chamber made from an ordinary camping cooler. If only a very few negatives need to be transferred, they may be sealed into a zip-closure bag.

The relative humidity inside the cabinet is kept stable because the cabinet doors close onto gaskets that limit penetration of outside (freezer) air, and other holes are covered or sealed. Of course, water vapour will seep inside over time because the seals cannot be perfect and outside air will rush in when the doors are opened for access to the collections. This water vapour is absorbed by a small amount of dried silica gel inside the cabinet, and by mat board which lines the tops and undersides of the shelves. The cabinet humidity is monitored, and the silica gel is replaced with newly-dried silica gel as necessary.

The advantages to this method are that efficient use is made of the walk-in freezer space because bulky packing materials are not necessary; and retrieval is straightforward because the negatives remain in their archival boxes. New location lists do not have to be created, and if only one negative needs to be retrieved, only one negative needs to be removed rather than an entire package.

Selecting the Cabinet

Part of the research in developing the gasketed cabinet method was the evaluation of suitable cabinets. The brand which kept the best seal without time-consuming modifications[44] was Viking[45]. There are no equivalent cabinets manufactured in Canada; Canadian museum suppliers will sell Viking cabinets with another name on the label. We selected model 336-15 from their Museum line, which was seven feet high, 39.5" wide and had six shelves 16" deep. We would suggest ordering one without a lock, which is redundant inside a locked freezer, and also without a vent, because it is slightly less expensive.

Preparing the Cabinet

It would be awkward and very heavy work to move the cabinet into the freezer with the shelves already installed, so we decided exactly where in the cabinet the shelves would be placed before it was moved. We marked the locations of the shelf supports on the inside of the cabinet so that we would not have to spend much time installing shelves at -18°C.

[44] Email correspondence with Mark McCormick-Goodhart, May 14, 2001.

[45] Viking Metal Cabinet Company.

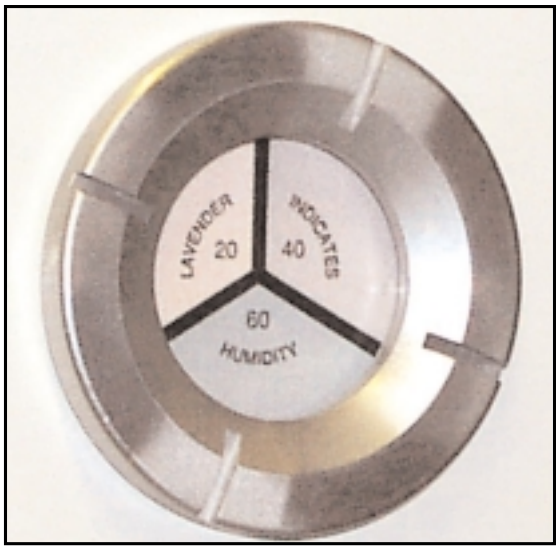

Figure 16. *Humidity plug with three-spot indicator card.*

Figure 17. *Viking cabinet with humidity plug installed.*

Purchasing and Installing the Humidity Plug

The humidity within the cabinet needs to be monitored on an ongoing basis. This could be done electronically using a wireless humidity monitor[46], or a data logger wired to give an external display. We chose to use a humidity plug, since it is the least expensive method. These plugs are only available from the U.S.[47]. We consulted with the supplier, and they felt that model 2175R was the appropriate one for the thickness of the metal door in which it would be installed. The humidity plug needs to be screwed through a hole in the front of the cabinet. The plug has a narrow gasket which seats itself in a channel in the plug, so the hole cut needs to be just the right size and cut in such a way that the metal is not deformed from a flat plane, so that a tight seal can be achieved. Cutting with a hacksaw would leave a jagged, lumpy edge. The easiest way to cut the hole is to use a knock-out, (formally called a Greenly punch). Electricians use them for punching holes, and some other tradespeople carry them. We asked some friendly workers who happened to be in our building installing a fire suppression upgrade, and they were happy to take five minutes to punch one hole. The knock-out bits are given nominal dimensions, which means that their actual diameters are different. We used a 1" bit, which gave a hole larger than 1". It was slightly too small for the plug, but we used a convex metal file to expand the hole until the plug fit.

[46] Make sure the sensor is reliable at very low temperatures.

[47] Manufactured by Süd-Chemie Performance Packaging; distributed by Texas Technologies. We requested a four-spot indicator card, 30/40/50/60%, #118-3456S.

The knockout bit of the next larger size was much too large. The Süd-chemie Web site advises using a 1.45" diameter hole, but this would be far too large. The plug was then simply screwed through the hole, with the supplied gasket on the outside, and tightened.

The plug was supplied with a three-spot, 20-40-60% indicator card. We replaced it with a four-spot 30-40-50-60% card in order to get a 50% spot. The indicator takes several weeks to acclimatise to the correct R.H. when in a frozen environment. It will not indicate R.H. accurately until it has acclimatised. We borrowed a data logger[48] to determine that the internal R.H. was at an acceptable value in the first few weeks of operation. When at -18°C, the spots on the indicator will not indicate the same R.H. as at 25°C. The 60% R.H. spot will turn lavender when the R.H. inside the cabinet reaches 40-43%, and that is the point at which the silica gel *must* be exchanged for freshly-dried gel. An early warning that the humidity is creeping toward the limit is given when the 50% spot turns pink, and the silica gel certainly may be exchanged then[49].

Preparing Mat Board

The mat board helps to buffer the cabinet humidity, especially when the door is opened. We cut two pieces of conservation mat board[50] to line each of the shelves. One piece was cut to the size of the top of the shelf, and the other was cut slightly smaller so that it would slip under and be suspended by the rolled edges of the underside of the shelf. We also cut one piece to sit on the floor of the cabinet.

Figure 18. *One pound of silica gel, packaged.*

Preparing Silica Gel

Only 1 pound (454 g) of desiccated silica gel is necessary as an additional water vapour absorbent within the cabinet, and it was suggested that it be divided into four packages and tucked into four corners of the cabinet[51]. Once the R.H. in the cabinet rises to 40-43%, as indicated by a lavender colour on the 60% spot of the humidity plug, silica gel is removed and replaced with freshly-dried gel. The silica gel would need to be replaced only every year or so, and the old gel could be re-used. If the cabinet was very full, and the door opened infrequently, the gel would

[48] Courtesy of the Archives Association of British Columbia Preservation Service.

[49] Email correspondence with Mark McCormick-Goodhart, November 26, 2002.

[50] We used 4-ply Rising Museum Mounting Board, available from framing suppliers, which has passed the Photographic Activity Test (P.A.T.) and so is safe to use next to photographs. Although any chemical reaction that the mat board would have with the photographs would be significantly slowed because of the low temperature of the freezer, the photographs are sealed in a closed space with the board without benefit of a vapour barrier between them, so this high-quality board was chosen. We required six sheets to line six shelves in one cabinet. For more information on the P.A.T., see http://www.rit.edu/~661www1/sub_pages/8page8.htm.

[51] Email correspondence with Mark McCormick-Goodhart, November 26, 2002.

last much longer. The cabinets used for the Smithsonian's research are fully loaded and have been used for three years without silica gel replacement[52].

Silica gel may be purchased[53] in bulk, or as pre-packaged Tyvek sachets[54]. We already owned a sufficient quantity of bulk silica gel, so that is what we used.

The silica was dried in a shallow pan at 120°C in a kitchen oven for 12 hours, then sealed in a metal container[55] while the packaging was prepared. The gel requires a package porous enough to allow air flow, and fine enough to contain the small beads of gel. We used white cotton gloves of a style our staff disliked, which solved two problems at once. The gloves were secured at the top by threading a string through the fabric, and tying a bow. One glove nicely held one-quarter of the silica gel.

Sealing the Door

Two styles of door mechanisms are available: a protruding, locking door handle and a recessed door handle with a separate lock. We ordered the recessed handle because we were afraid the protruding one would hit the freezer walls and other cabinets and cause damage. That worry seems to have been needless, but the recessed handle produced an unexpected problem.

Although the gaskets seal the cabinet along the door edges, there are still a couple of places where humidity could intrude. This would not be a problem if the cabinet was being used for its original purpose of excluding dust, but when keeping out moist air we have to be concerned about every tiny crack. The lock is a hole that goes right through the door. On the cabinet models with latch-style handles, the lock may be sealed with aluminum tape. Our cabinet has a recessed handle, so as well as the lock, the metal faceplate around the handle and the point at which the handle penetrated the door were both possible sources of leakage. We attempted to seal the lock, handle and faceplate with a piece of flexible magnetic sign material[56], the kind that is used to put a temporary corporate sign on the side of a truck. There were too many protrusions from the front of the door, in the form of bolts and the lock, for the magnetic material to lie flat and seal properly. We removed the lock and taped over the resulting hole with metal tape. It was suggested[57] that we create an overlay made of a doughnut shape of magnetic material, with a flexible centre of Marvelseal attached with metal tape. This worked, but is fussy to use, as it has to be positioned within lines we drew on the outside of the cabinet, and the edge closest to the centre of the cabinet has to be rubbed flat whenever the cabinet is closed and resealed. Next time, we will be buying cabinets with protruding handles.

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[52] Email correspondence with Mark McCormick-Goodhart, November 26, 2002.

[53] Available from Carr-MacLean and University Products. Do not purchase preconditioned gel: use the plain silica gel beads sold as a desiccant.

[54] Various suppliers. One type is Natrasorb S, from Multisorb Technologies Inc.

[55] Raymond H. Lafontaine, *Technical Bulletin No. 10*, Canadian Conservation Institute, Ottawa, 1984, page 4. They suggest using a new, clean paint can for storing dried gel.

[56] Email correspondence with Mark McCormick-Goodhart, November 28, 2002 and February 3, 2003; he sealed his experimental cabinets this way, but the ones he received from Viking were slightly different in configuration than ours, so this method worked easily for him.

[57] Rosaleen Hill, British Columbia Archival Preservation Service Coordinator.

Figure 19. *Magnetic/Marvelseal handle cover.*

The Viking cabinets are available with or without a vent in the door. In museum applications, the vent allows the option of allowing some fresh air to circulate occasionally. In this application, we do not want any outside air to enter, so we ordered it without a vent. What we received was a cabinet with a vent hole with a metal mesh filter which had a metal-and-rubbery-foam seal on the outside. Unsure of what the rubbery seal might off-gas, or how well it would perform as a seal at -18°C, we sealed from the inside by detaching the gasket, pushing the mesh inside the hole to make it flush, and covering it with a piece of magnetic sign material. Subsequently, we discovered that the rubber was silicone and safe to leave alone[58].

Moving the Cabinet into the Freezer

We locked the empty cabinet to stabilize it for moving. It is heavy, and needed to be put on its side to fit through all the doors in our building. It was very important that it not be dropped or damaged during transport, as the fit of the doors is critical to the success of

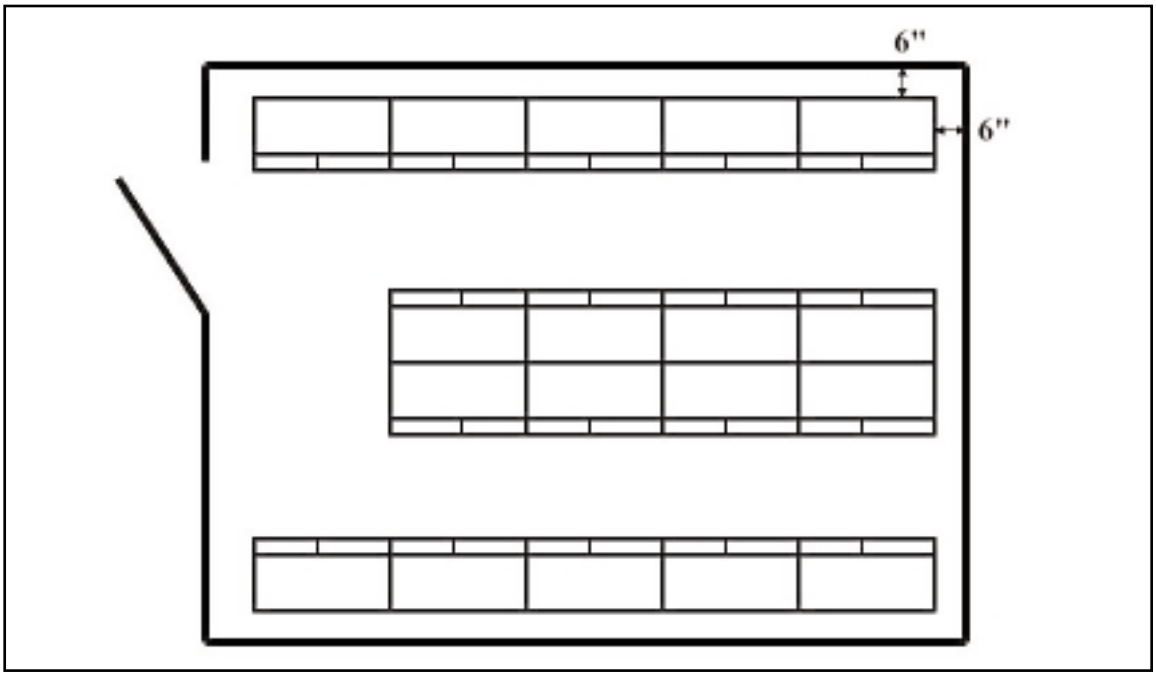

Figure 20. *One possible cabinet placement scheme, with cabinets six inches from interior walls.*

[58] Email correspondence with Mark McCormick-Goodhart, February 3, 2003.

this method. Two strong individuals and a padded dolly were necessary. The cabinets must be positioned 6" from the walls of the freezer, but cabinets may be butted next to each other[59].

Levelling instructions came with the cabinet. The floor of our freezer is almost perfectly level, and the cabinet was level when we placed it on the floor, but the doors did not meet in a perfectly straight line across the top, so we attempted to adjust the level. Levelling is done from inside the cabinet: screwed caps in the floor are removed, and the levelling feet are adjusted using a socket wrench until the doors line up flush top and bottom. We could not get the levelling feet to rotate at all. In the end, the manufacturer sent us plastic washers to lift one door so that it was level with the other. We made sure to screw the caps back into the floor, as they covered four fairly large holes.

If the cabinet is levelled using the levelling feet, it will no longer be standing on the long pieces of rolled metal that make up the base, but will be perched on four small feet. Once the cabinet is loaded, this will put tremendous pressure on the freezer floor on those points. It is possible to pay extra for a heavy-duty floor when the freezer is purchased, but a cheaper solution is to place the cabinet on a piece of wood to spread out the load. In the research done for the Smithsonian, 1" plywood was used for this purpose, painted with latex paint to stop it from off-gassing harmful vapours[60].

Making and Using an Acclimatisation Chamber

The negatives should not be put in or taken out of the freezer without proper acclimatisation. Unpackaged materials entering the freezer would cool more quickly on the outside, producing a temperature gradient which would encourage moisture migration[61], causing the box to become damp. Unprotected material removed from the freezer to a warm room would also create a temperature gradient, and would have moisture condense on all outside surfaces. Allowing the temperature to change slowly will mean the temperature will change more evenly throughout the boxes, avoiding the creation of severe temperature gradients. This acclimatisation chamber will allow the temperature to rise or fall slowly, and will keep the relative humidity of the photographs within a safe range.

Very small quantities of negatives, such as one or two, may safely be transferred in or out within a zip-closure bag. There would not be enough material to cause a significant thermal gradient, and the negatives warm and cool quite quickly and evenly. When removing a single negative from the cabinet, it should be quickly bagged and zipped within the freezer, removed, and allowed to warm to room temperature. When replacing the negative inside the cabinet, it should be bagged at room temperature, placed inside the freezer to cool, then transferred from the bag into the cabinet.

When larger quantities are moved, they must be transferred inside a chamber which is vapour-proof, insulated to retard quick temperature changes and which allows monitoring of the temperature of the contents. Several boxes of negatives would take hours or days

[59] Email correspondence with Mark McCormick-Goodhart, November 26, 2002.

[60] Email correspondence with Mark McCormick-Goodhart, November 26, 2002.

[61] Email correspondence with Mark McCormick-Goodhart, January 13, 2003.

to warm or cool depending on the volume of material and initial and target temperatures of the contents. It would be difficult to guess when the correct temperature had been reached.

We used a modified[62] camping cooler[63]. The bottom was lined with two one-half inch sheets of Styrofoam trimmed to fit. At the centre, a rectangle of foam was cut out to accommodate a wireless temperature transmitter[64] so that its sensor lay flush with the Styrofoam. A wireless unit is tidy, but a slightly cheaper alternative is to thread a wired temperature probe through the drain hole, covering the hole with metal tape to exclude moisture transmission. We thought the convenience of the wireless unit was worth the small extra expense.

Figure 21. *Acclimatisation chamber with wireless thermometer installed.*

Figure 22. *Thermometer receiving unit.*

To use the chamber to bring boxes into the freezer, we started with the chamber at room temperature. The boxes were loaded inside on top of the transmitter unit, the lid tightly closed and the chamber moved into the freezer. When the temperature inside the chamber, as read on the receiver unit, was the same as the temperature inside the freezer, the boxes were quickly transferred into the cabinet. Before loading more boxes, we allowed the chamber to warm to room temperature once again.

To remove boxes from the freezer, we will follow the above steps in reverse. The chamber will be cooled to the freezer temperature. Full boxes of negatives will be placed on top of the transmitter and the lid will be shut. The chamber will be removed and the receiver

[62] Mark H. McCormick-Goodhart, "Simple Staging Method for Removal of Materials from a Cold Vault", undated, unpublished memo. Explains and illustrates the chamber design.

[63] Coleman Wide Body 50-quart plastic insulated cooler. The wide design accommodated two 5" x 7" shoe-style negative boxes placed across the width and one stacked on top; other coolers of a similar volume only fit two.

[64] Radio Shack Wireless Thermometer 63-1026, consisting of up to three remote sensors and one receiver unit which displays the indoor (room temperature) and outdoor (cooler) temperatures simultaneously.

Figure 23. *Cabinet loaded with 48 boxes.*

unit monitored. When the temperature within the cooler has warmed to the temperature immediately outside the cooler, it will be safe to remove the negatives.

The only complication would occur if it was necessary to move a partly filled box. With only the cooler, a box and a small volume of negatives, there might not be enough total thermal mass for safe staging of the materials[65]. It might be necessary to add extra thermal mass inside the cooler in the form of additional non-collections materials that are at the initial temperature (for example, already chilled to -18°C if materials will be retrieved from frozen storage).

To illustrate, our cabinet held a total of 48 5" x 7" shoe-style boxes of negatives. To load the cabinet, we transferred eight full boxes at a time, requiring six loads. We used four separate coolers: the Archives cooler and three loaned by staff. It took, for instance, the wide-body Coleman cooler loaded with 1.5 kg of materials about 36 hours to cool to -18°C. The other coolers took a similar but not identical time period for cooling. It depended on the construction of the cooler and the weight of negatives in the load. We have not yet had to warm any materials for retrieval.

Results

We used our cabinet to store uncatalogued acetate negatives from the Williams Brothers Photographers Ltd. fonds. This valuable collection has a very high retention rate, so we are confident that very little of the material will be discarded once these items are appraised and described. The material is housed in its original envelopes, in the same state it arrived from the photographer. Many negatives may be filed together in one envelope, which might also contain a print. The photographer had filed the negatives in 5" x 7" envelopes whether they were 4" x 5" or 5" x 7" format, so we housed them in 5" x 7" archival photograph boxes. We estimated, from counting and weighing a 6" sample, and then weighing all the material before it was frozen, that our single cabinet houses about 50,000 frozen negatives.

The cabinet method is easy, requires little maintenance and is an efficient use of time and space. Although the cabinets are not inexpensive, they can be purchased as part of an ongoing rehousing program over many years.

[65] Email correspondence with Mark McCormick-Goodhart, November 26, 2002.

Conclusion

We are in a position to compare the cost and efficiency of both the CMI and the gasketed cabinet method, having used both on collection materials of similar formats. We spent about $5,000[66] for all the supplies (board, bags, RH indicator squares, boxes, etc.) to house 113,000 negatives using the CMI method. We saved money, and had some supplies left over for future use, because we purchased in bulk. The gasketed cabinet method requires a walk-in freezer (ours cost $25,000[67]), and an acclimatisation chamber (about $100 for cooler, thermometer and foam). After that, it will cost us about $3,000[68] per cabinet including customs, crating, and shipping to Vancouver from Chicago. Shipping charges, which are considerable, are reduced per item when multiples are ordered. One cabinet houses about 50,000 negatives.

The gasketed cabinet method offers dramatic labour savings over the CMI method. Preparing and loading the first cabinet took a few days, and the next time it will be faster. Preparing the CMI materials (cutting, grinding and drying the boards, and assembling the boxes) and packaging the negatives took months. Space savings are equally impressive. We estimate that 50,000 negatives packaged using our CMI adaptation would occupy 50% more volume than the same number in a gasketed cabinet. As the space in the freezer is finite and expensive, this is an important advantage.

More options exist today for the cold storage of negatives than when we first looked for solutions in the early 1990s. Creative use of these ideas can allow even a small, poorly funded institution to preserve their photographic collections to the highest possible standard.

[66] Price in 1999.

[67] Price in 2001.

[68] Price in 2003.

Appendix I: Suppliers

Carr McLean Ltd
461 Horner Avenue
Toronto, ON M8W 4X2.
Tel: 1-800-268-2123

Envimaco International
8170 Devonshire
Montreal, QC H4P 2K3
Tel: (514) 731-1550
Fax: (514) 731-2535

Image Permanence Institute
Rochester Institute of Technology
70 Lomb Memorial Drive
Rochester, NY 14623-5604 USA
Tel: (585) 475-5199
ipiwww@rit.edu
http://www.rit.edu/~661www1/

International Plastics
185 Commerce Center
Greenville, SC 29615-9527
Tel: 1-800-433-4043
(864) 297-8000
http://www.interplas.com/

James Dawson Enterprises Ltd.
440-19th Avenue, Room 340
Lachine, QC H8S 3S2
Tel: (514) 637-6721

Light Impressions
P.O. Box 787
Brea, CA 92822-0787
http://
www.lightimpressionsdirect.com

Metal Edge
6340 Bandini Avenue
Commerce, CA 90040
Tel: 1-800-862-2228
http://www.metaledgeinc.com/

Multisorb Technologies, Inc.
325 Harlem Road
Buffalo, NY 14224-1893
Tel: 1-888-SORBENT (works from Canada)
http://www.multisorb.com/index.html

Süd-Chemie Performance Packaging
926 S. 8th Street
Colton, CA 92324
http://www.sud-chemie.com/

Texas Technologies
P.O. Box 3878
Cedar Park, TX 78630
Tel: (512) 267-0100 or
(800) 858-1379
info@texastechnologies.com
http://texastechnologies.com/

University Products of Canada
6535 Millcreek Drive, Unit 8
Mississauga, ON L5N 2M2
Tel: 1-800-667-2632
http://
www.universityproducts.com
(US site)

Viking Metal Cabinet Company
5321 West 65th Street
Chicago, IL 60638
Tel: (708) 594-1111
http://www.vikingmetal.com/

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Appendix III: Press Release

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CITY OF VANCOUVER **news release**

City Hall, 453 West 12th Avenue, Vancouver, BC V5Y 1V4 (604) 873-7011 www.city.vancouver.bc.ca

February 18, 2002

City Opens New Photo Storage Facility

Mayor Philip Owen will cut the ribbon on a new cold-storage facility for historical photographs:

Wednesday, February 20, 2002 at 11 a.m.
City of Vancouver Archives
1150 Chesnut Street

The 1,600-cubic-foot, walk-in freezer is located in the existing Archives building, and is one of only three such facilities in Canada. Capable of storing hundreds of thousands of images at -18 C, the freezer will preserve deteriorating photographs in the Archives' collection to the highest standard of care currently available. Without frozen storage, these unique negatives would deteriorate in many ways: the images would disappear, colours would fade and the emulsions could wrinkle severely.

Frozen photographs need to be stored in a stable and low-humidity environment. The new freezer, combined with special moisture-absorbing packaging (newly-developed by the Smithsonian Institute) will help preserve these historic images for many years. Previously stored off-site, the images can now be stored at the Archives and closely monitored. Other collections at risk may also be frozen.

The City Archives cold storage facility is funded by the Friends of the Archives Society.

Media enquiries:
Sue Bigelow
City of Vancouver Archives
(604) 736-8561

Appendix IV: Media Handout

In its original form, this was a one-page, double-sided handout distributed in person to media at the opening, or by fax upon request.

Friends of the Archives Photographic Cold Storage Facility

What is it?
It's a walk-in freezer that the City of Vancouver Archives is using to preserve its most vulnerable photographic negatives. It was built in December 2001, tested in January 2002, and was dedicated February 20, 2002 . It was funded by the Friends of the Archives society.

Is it the same as the freezers that restaurants have?
Pretty much. Some wiring was adjusted, and extra sealing of seams was done in order to keep the inside air drier than commercial freezers.

Why is the Archives excited about a freezer?
Only three public archives in Canada have walk-in frozen storage units for their photographs, ours, the National Archives, and the Provincial Archives of Manitoba. Cold storage at refrigerator temperatures will extend the life of deteriorating photographs somewhat, but frozen storage is acknowledged as the highest standard of care. We are pleased to be able to give our collections the best chance for long-term preservation.

Which images are most vulnerable?
The negatives which are most at risk are cellulose acetate (1934-present), cellulose nitrate (1893-1940s) and colour (1930s-present). We surveyed our collections to determine which collections containing these materials were deteriorating most rapidly, and froze those first. In the case of the acetate negatives, we surveyed the collections using A-D (acid detecting) strips, which change colour to indicate the level of deterioration. Many of our acetate negatives had only a few years left before they were severely disfigured by their deterioration.

What happens to these photographs if they are stored at room temperature?
Cellulose nitrates: The gases they give off as they deteriorate react with air to give nitric acid, which attacks the silver image, eventually destroying it so there is nothing left to see. At the same time, the negatives become dark brown, gooey and smell acrid.

Cellulose acetates: The plastic base, which is sandwiched between two layers of emulsion, gives off acetic acid ("vinegar syndrome"), as much as one tablespoon of vinegar for a 4"x 5" negative. Having lost so much of its volume, the plastic shrinks, pulling on the emulsion and causing it to wrinkle all over. Other elements in the base can cause bubbles and crystals to form. The result is that any copies made of these negatives are obscured; a clean copy cannot be made.

Colour: The colour photographs in the Vancouver Archives are coloured by dyes, which fade even if kept in the dark. Low temperature storage is the only way to ensure the colours don't fade any further.

Why didn't the Archives do this years ago?
Photographic conservators have known for years that cold storage—the colder the better—was the best way to slow the deterioration of negatives. The complication was that they also knew that the relative humidity (RH) of the cold space had to be kept low (between 20-40%). The only way to do that used to be to install expensive, finicky and energy-greedy dehumidification controls on the freezer.

In the mid-1990's, research at the Smithsonian Institution produced a storage method which controlled the RH within individual packages rather than the entire freezer, allowing negatives to be stored in a conventional freezer. Knowing that we needed to act quickly before our acetate negatives would become wrinkled, we packaged 113,00 images into ziploc-style bags with dried mat board, packed them onto a pallet and stored them in a large commercial freezer facility mainly used by food distributors. Access to the images was difficult, but our priority was to freeze the negatives immediately, then try to build a freezer of our own.

Which collections are in the freezer now?
Presently, we have 113,000 images frozen from two major collections which have been certified by the Cultural Property Review Board as having national significance.

Don Coltman/Steffens-Colmer fonds: These photographs document leading western industries, wartime activities, interiors of hotels and department stores, and a record of people at work. The war years, 1940-1945, document official activities such as the Air Raid Patrol, propaganda and fundraising, as well as a look at life in wartime Vancouver.

Jack Lindsay fonds: This commercial photographer documented major corporate clients (Famous Players, B.C. Tel, CBC, BC Electric) over a long period of time (10 to 41 years). As well, he worked as a photojournalist for the News-Herald, documenting significant events such as the evacuation of Japanese Canadians in 1942, the "Greenhill Park" explosion in 1945, the demolition of Ripple Rock and the arrival of the "St. Roch". *(N.B. He was Vancouver Sun photographer Ian Lindsay's father.)*

Why don't you just scan everything?
We do have an ongoing program to scan our images to provide easier access and printing. With over 1.3 million images, scanning is a very long-term project. By the time we got to many of these images, they would be gone if they were stored at room temperature.

Photographic negatives contain much more information than we can capture in a scan. Our scans are not intended to replace the negatives, just to allow them to spend most of their time in cold storage while the scan is used a reference for researchers.

What's next?
The mat-board-and-ziploc storage method was intended for small collections; we used it because it was the best method available at the time. The Smithsonian has since researched a storage method, still unpublished, in which the RH is controlled within gasketted cabinets. This allows the photographs to be stored in paper envelopes, without the bulky and time-consuming repackaging used in the mat board/plastic bag method.

The Archives plans to be the first archives in the world to use this new method.