VMS ice analysis procedures and preparation of ice sheet summaries

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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/8894839
Laboratory Memorandum (National Research Council of Canada. Institute for Ocean Technology); no. LM-2006-05, 2006

National Research Council Canada
Conseil national de recherches Canada
Institute for Ocean Technology
Institut des technologies océaniques

Laboratory Memorandum

LM-2006-05

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March 2006

Canada

DOCUMENTATION PAGE

REPORT NUMBER	NRC REPORT NUMBER	DATE		
LM-2006-05		March 2006		
REPORT SECURITY CLASSIFICATION Unclassified		DISTRIBUTION Unlimited		
TITLE **VMS ICE ANALYSIS PROCEDURES AND PREPARATION OF ICE SHEET SUMMARIES**				
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PUBLICATION				
SPONSORING AGENCY(S) Institute for Ocean Technology, National Research Council, St. John's, NL				
IOT PROJECT NUMBER 42_10_10		NRC FILE NUMBER		
KEY WORDS Datatrieve, ice analysis, model ice, ice sheet summaries		PAGES iv, 20	FIGS.	TABLES

SUMMARY

This report briefly describes all the VMS ice analysis procedures used in the course of summarizing the ice sheet properties. Instructions are given in how to use them and how to edit and copy files and how to prepare all the ice and temperature information for inclusion in the ice sheet summary reports. Archiving of ice sheet data is also described.

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VMS ICE ANALYSIS PROCEDURES AND PREPARATION OF ICE SHEET SUMMARIES

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VMS ICE ANALYSIS PROCEDURES AND PREPARATION OF ICE SHEET SUMMARIES

1.0 INTRODUCTION

This report briefly describes all the ice analysis procedures used in the course of summarizing the ice sheet properties. This includes notes on why it is done the way it is, the correct syntax or format to use, and some notes on how to correct errors, because the routines in Virtual Memory System (VMS) on the Virtual Address Extension (VAX) computer are not very forgiving. All the VMS procedures are described, as are notes on how to reduce the temperature information stored by the refrigeration PC during the ice sheet preparation. The summarizing of the information and preparation of the graphs that comprise the final ice sheet summaries are described, as is the archiving of the data.

1.1 History

All the VMS analysis routines have basically the same functions: calculate and summarize the data so that the values can be presented in a simple document that the client can be presented with very quickly, and to preserve the data in the database. The data is stored in the VMS database, Datatrieve, and with over 1000 ice sheets summarized is probably unique in the model testing world. The routines were programmed at a time when everyone was using VAX workstations and Tektronics plotters for graphing, and when PC's were almost unheard of. The ASCII point (.pnt) files are a leftover from those days being used for curve fitting on the old graphics, but they can still be used very easily by importing into spreadsheets such as Excel. Moves are underway to update the software and database to a PC system but that could still take a while.

1.2 Key Points

In all the procedures use upper case. Datatrieve is case sensitive so a search to find "KALVIK" will not find "Kalvik" or "kalvik". For a new ice sheet the warm-up program has to be run first as that creates the necessary files with the new ice sheet name in the test directory and Datatrieve.

1.3 Test Directory (Test_Dir)

All subsequent files created are written to a Test Directory that has been assigned to "Test_Dir" in your login.com file which is automatically run every time you login to the VMS. The original idea for this was that the Project Manager would create an appropriate directory for the files but it has now evolved to writing and keeping the files all in one place being one of my own directories, DISK$PROJECT2:[PJ88084.ICEDAT], but which everyone has access to. There are now over 3,000 files there since 1995. Files prior to that time were transferred to an ice data directory that no one can now locate which highlights the necessity of maintaining the cardboard file backups which extend back to Ice Sheet #1. Before running any of the ice procedure routines the command ASSIGN DISK$PROJECT2:[PJ88084.ICEDAT] TEST_DIR should either be in your login.com file or entered at the screen prompt at the beginning of each session.

2.0 ICE ANALYSIS PROCEDURES

This section describes each of the ice analysis programs. For each ice sheet “Warm-up” has to be run first which checks Datatrieve, assigns a unique ID number and creates a log file in the Test_dir. There is an analysis program for each of the ice properties the function of which is to create a text file containing the original measurements and the calculated values, and also to append the log file with an average of these values. Once all the ice properties have been added, additional programs create summary sheets and write the information from the log file into Datatrieve. In two particular cases, those of Flexural Strength and Ice Thickness, a third file is written in .pnt format for ease in plotting the values.

2.1 Warm-up (RUN ICE_ANALYSIS$:WARM_UP)

Since Datatrieve requires additional security protection only I, or persons using my account, can use this program (I am not sure if there is now anyone in the building who knows how to authorize new users, anyway). This program first checks Datatrieve to see if the ice sheet name is unique and will display Datatrieve OK. If it is not, it will tell you and return the information on the original sheet and you will have to re-run the program with a different name. If the name is unique the program will continue and prompt for:

> **Date of Warm-up.** Be careful, this may not be the same as the test day and be sure to follow the format of the prompt with 2 digits each for the month and date in the correct order and 4 digits for the year.
> **Time of Warm-up.** Again follow the format with 2 digits each for the hour and minutes. The time is the actual time of warm-up that the refrigeration operator prints out (or can be obtained from the refrigeration data .cz file), not the time given in the Ice Tank schedule which is an approximation.
> **Project Number**. The number of digits (no alphabetic characters) is limited to 5 so just use the current project number
> **Project Officer**. Use the format as in BHILL to conform with existing entries.
> **Ice Type**. Select M for (M)odel unbubbled ice, B for CD (B)ubbled ice and F for (F)reshwater ice.

If you spot a mistake in one of your entries before the end of the program you can use Cntrl C to end it and then re-run the program. Otherwise, the program will continue by writing to the database. If at any time you get a message such as “Sorry DATATRIEVE initialization failed” then let your supervisor know or contact Computer Systems. Sometimes, after system backups or downtimes the correct disks do not get mounted.

An ID number is automatically assigned to the ice sheet name and the information just entered is stored in the Ice Project domain in Datatrieve, and a log file is created in the test directory. The header in the log file contains the ID number, Julian day, time of warm up, day of week and an indicator which ice type is being used.

If an error in the test name, date, or time gets written into Datatrieve then this has to be corrected before any further programs are run so let your supervisor know right away. Generally, this means deleting all information from the database, erasing the log file and starting all over again.

2.2 Flexural Strength FLEX (RUN ICE_ANALYSIS$:FLEX)

The downward flexural strength is probably the most important mechanical property of the ice that is measured. The raw data is entered at the prompts remembering to use upper case and identifying which side of the tank, (N)orth or (S)outh, the measurement was taken because the sides of the tank are treated differently and tempering curves established for each. Once the raw data for the beams has been entered, the program displays the information just entered with the option of correcting any mistakes. It is time consuming to check each value but a quick scan with the eye should identify any anomalous values. If an error is detected after this stage but before the program ends, the program can be terminated with a Cntrl C or Z and then re-run. The program also prompts for upward breaking beams which in comparison with downward breaking beams is a measure of the anisotropy of the ice. Normally just one beam per set is broken upwards but in ice tests where the ice is broken upwards (such as in an upward breaking cone) at least three should be done for better accuracy. The program then prompts if any values should be deleted from the set. See Section 4 for guidance in doing this. The information that is entered is automatically written into three separate files: the text .flx file; the point file; the log file. If an error is detected after the program has been run, the mistakes have to be edited or deleted in all three files. In the .log file, four lines of data may have to be deleted: the first contains the average downward strength for the set of beams, the next contains the average thickness for those beams, the next the average upward upward strength, and the last, the average thickness for the upward beams. The upward strengths are not written to the .pnt file, so if a tempering curve using these values is required they have to be extracted from the log file or text .flx file.

The Flex program can be run any number of times, the data appending to the .flx, .pnt and .log files. A graph can easily be plotted from the data at any time by importing the .pnt file to Excel, for example, (see Section 7.2.3).

2.2.1 Estimate the time to target strength

The Flex program concludes by prompting if the user would like to estimate the time to target strength based on the entered data but this can only be done if more than one pair of north and south values have been entered. The displayed estimate is based on an exponential curve fit and the routine can be repeated for any number of values. If there are still any incorrect flexural strength values in the log file still these should be corrected as they will affect the results. The results of this calculation are not stored anywhere, just displayed on the screen, but this part of the program can be re-run at any time by using the TEMPER program (see Section 2.5 below). Unless the target strength value is very low the estimated time to target strength is typically sooner than predicted since the exponential fit assumes a flattening of the curve whereas except for very low values one is normally operating in the steeper part of the curve.

2.3 Thickness THICK (RUN RUN ICE_ANALYSIS$:THICK)

Perhaps the next most important ice parameter is the ice thickness. Similarly to the flexural strength program the information is written to a text file (.thk), appended to the .log file and can be appended to the .pnt file. The program assumes one is measuring from a model track through the ice so requires data from both sides of the channel at regular intervals, and also needs to know whether the channel is in the Centre of the tank, or the North or South Quarter Point. The program prompts for the location of the channel, the location of the first and last measurement and the step interval of the measurements. These intervals can be any integer from 1 meter to the total distance of the channel but for convenience should be equidistant through the channel, typically every 2 meters. For non-routine kinds of tests such as arcs with the PMM (Planar Motion Mechanism) then the program should be used as is but with appropriate comments edited into the .thk file. When all the data has been entered, it is re-displayed on the screen to allow for the option of correcting any mistakes. It is much easier to correct them at this stage as once the program terminates as many as three files may have to edited and the many data points re-entered. The program also allows the information to be stored as point files for later plotting. If this option is accepted the program will prompt for Tag No.'s. This is no longer as meaningful now as it once was as the old plotting routines are redundant but since an entry is still required enter 1,1 for Center channel, 2,1 for the north and 3,1 for the south. The program ends by asking if the user wants to calculate the mean thickness. This is a very useful utility, and at the very least, the mean of all values should be calculated.

2.3.1 Entering Initial Ice Thickness.

While this data is not from along the model track it can be treated as such by entering the data as a center channel from 20 m to 60 m at 20 m intervals. The values from this are not normally plotted so writing to the point file is not normally done though the mean calculation from 20 to 60 m is required. This value is needed in the Ice Sheet Summary (see Section 2.11 below) and is stored in the Datatrieve database where it is used in ice growth calculations.

2.3.2 Entering Channel Thickness.

Enter the data at the appropriate prompts and answer with a yes for writing to the .pnt file. If a .pnt file is already in existence (which it probably is since it is likely that the Flex program will already have been run at least once) then a prompt will appear if you want to append to it. Three sets of data are written; one for the north edge of the channel and one for the south edge of the channel, and these contain the measured thickness at each location along with ratio of the thickness at that location to the mean thickness, while the third set is the average thickness of both north and south at each location along with the thickness ratio. The .pnt file can be easily imported into Excel where the third set containing the average of both values is normally plotted against Tank Position to view the thickness profile down the length of the tank (see Section 7.3 below). The thickness ratio can be used in the same way and has the advantage that the Y axis scale is always the same so it is useful in command procedures or when comparing variations in ice sheets of different thicknesses.

The mean thickness calculator at the end of the program should be used to establish the mean for the whole channel, and also the constant speed distances (or any other distances) of the model track. The mean thickness of the center channel when measured at or near the time of the target strength is the Final Ice Thickness of the ice sheet and is required for the Ice Sheet Summary (see Section 2.11 below), and is also eventually stored in Datatrieve where it is used in ice growth calculations. The mean channel thicknesses for each side of all the model tracks are automatically calculated and entered into the .log file but using the calculator option also means that the average thicknesses from both sides of the channel are written to the text .thk file and provide easy reference for the summaries.

2.4 Flexural Strength Correct FLEX_COR (RUN ICE_ANALYSIS$: FLEX_COR)

This program is used to correct the values from a beam survey taken down the length of the tank on either side of the model track to the time of the model test. Since the ice is always tempering and the beams cannot be measured all at the same time this offers a method of estimating the ice strength at various locations corrected to the same time as the model test. This program calculates these values from the tempering curve defined by the beams normally taken at the center of the tank and entered into the flex program. Consequently, all the beams for the tempering curve should be entered before running this program. The program concludes by asking if you want to write to the point file. This is really only of use if a number of locations have been corrected to the same time so that the variation of flexural strength with tank position can be plotted.

The time corrected values can be summarized on the “Ice Sheet Properties and Location Diagram”. This is a simple diagram of the ice tank on which the values of the beams can be written at the appropriate location to give the user or project manager a quick idea of flexural strength variation. The information should be kept simple and easy to read rounding off average beam values to the nearest whole number.

2.5 Tempering Curve TEMPER (RUN ICE_ANALYSIS$:TEMPER

This is a convenient program that can be run independently on any sheet at any time and will calculate the strength of ice based on the tempering curve for any given time, or calculate the amount of tempering time required to reach a certain flexural strength. It can, therefore, be run on the current ice sheet to estimate when the model test time will be, or can be run afterwards to estimate what the ice strength was at a particular test time.

The calculated results are not stored so if a record is required the screen text should be printed.

2.6 Elastic Modulus MOD (RUN ICE_ANALYSIS$:EMOD)

This is the program to calculate the elastic modulus and is straightforward to run but there are a couple of things to watch out for:

1) The calibration constant for the LVDT is written into the software code so cannot easily be changed, but the user is prompted each time the program is run to accept the default value or change it. This, then, should be changed to the current calibration constant in mm/v.
2) The software was written with the use of the Gould chart recorder in mind with the number of chart divisions at a known scale of volts/division. Any recording device can be used, however, as long as the units conform to this format.

The program terminates by writing the raw data to the text .mod file, and a summary of the calculated values to the .log file. Three lines are written to the log file, one each for the modulus value, the characteristic length (Lc) and the thickness, so in the case of errors all three lines will have to be deleted. As a guide, values for modulus should give a ratio of modulus to flexural strength of 1,000 to 4,000 with the lower end values for thin ice sheets and the higher end values for thick sheets. The ratio of characteristic length to thickness should be in the range of 10 – 13 for all sheets (perhaps a little higher for thick or really tough sheets). Any deviation from these ratios would be worth investigating.

2.7 Density DEN (RUN ICE_ANALYSIS$:DEN)

This is the program to calculate the density and is straightforward to run. It allows more than one sample to be run by answering Yes at the appropriate prompt. The default plunger weight can be changed if using a different test technique such as in-situ with large blocks of ice from ice sheets greater than 10 cm and from ice ridges. The program terminates by writing the raw data to the text .den file, and the calculated values to the .log file where the density and average value for thickness are written. Typical values for unbubbled ice are in the range 0.92 to 0.95 with density increasing with deceasing strength and thickness. For CD ice, the normal target is 0.885 so an average of two samples from typical areas of the ice sheet should not be too different from this value.

2.8 Compressive Strength COMP (RUN ICE_ANALYSIS$:CMP)

This is the program to run the compressive strength calculation. It prompts for the measuring system being used, the Chatillon, the MTS or in-situ, each system having a different stiffness and possibly giving slightly different results. The Chatillon and in-situ methods assume, as in the case of the elastic modulus, that the Gould chart recorder is being used, but any recording device can be used as long as the units conform to this format. The program also prompts for the current calibration value. If the field equipment ATS is used then the MTS option can be used since they are mechanically similar. The program option requires the known load or force at failure to be entered along with the sample dimensions. If the in-situ method is used then there are further prompts to define the breaking pattern. The program terminates by writing the raw data to the text .cmp file, and the calculated values to the .log file where the average values for compressive strength and thickness are written. Typical compressive strength values are three time the flexural strength.

2.9 Shear Strength SHEAR (RUN ICE_ANALYSIS$:SHR)

This is the program to run the shear strength calculation and is very similar to the one for compressive strength since the equipment used to measure it is largely the same. The program terminates by writing the raw data to the text .shr file, and the calculated values to the .log file where the average values for shear strength and thickness are written. Typical shear strength values are 1 to 1.2 times the flexural strength.

2.10 Friction Determination FRICTION (RUN ICE_ANALYSIS$:HULL_ICE_FRICTION)

This is the program to determine the coefficient of friction between the hull coating and ice. The program is straightforward to use and assumes a chart recorder is being used (see Work Instruction TNK-32, but any recording device can be used as long as the same format is followed). Although the program can be run at any time it is best to wait until all the flexural strength data has been entered since it calculates the ice strength at the time of the friction measurement based on the tempering curve. The data and results are saved to a text .hif file and a summary is written into Datatrieve. The program can be halted at any time using Cntrl C but if errors are written then it would be best to delete the .hif file, and the database records, and re-run the program.

2.11 Creating the Mechanical Properties Summary SUM (RUN ICE_ANALYSIS$:SUMMARY)

This is the program that writes the information in the .log file to the text .mps (**m**echanical **p**roperties **s**ummary) which when printed out, is part of the final summary document. Before running the program, obtain the model test times and run those times on the Temper program taking note of the calculated strengths for each time. On running the Summary program for the first time on an ice sheet, say “N(o)” to the prompt of writing the information to Datatrieve. The text summary will still be created and it is best to check this over carefully for mistakes and correct them before writing to the database and having to make tedious edits there. At the prompt when it asks if one wants to calculate strength at run times, the normal response would be Yes. One can enter as many times as one wants but one has to tell the program initially how many runs there are to be entered and if all the runs were done on the same day. It is possible to test thicker sheets over 2 days.

2.11.1 Checking the summary

Once the program has run, obtain a print out of the summary and go over it carefully looking for errors. It is best to go over a paper copy than on the screen because of special formatting which looks awkward on the screen. The data is presented in columns, in order as follows:

Time	(Real time in hours and minutes)
Warm-up hrs.	(Time since start of warm-up in decimal hours)
Loc	(Tank position and if north or south)
Hi	Average thickness in mm. If it is the average thickness from a profile then the standard deviation with number of samples for N and S is given. An average thickness is also given for each mechanical property but without the standard deviation and number of samples
δ_f	Flexural Strength in kPa. First line in entry is the downward breaking beams with standard deviation and number of samples. The next line is the upward breaking beam with the upward to downward ratio (u/d) ratio in brackets.
Lc	Characteristic Length in cm.
E	Elastic modulus in MPa
E/δ_f	Ratio of modulus to flexural strength. Should be in the approximate range 1000 – 4000.
Lc/Hi	Ratio of characteristic length to thickness. Should be in the approximate range 10 – 13.
K1c	Fracture toughness in N/m. Currently not normally done.
δ_f /K1c	Ratio of flexural strength to fracture toughness. Not normally done anymore but would give a value in the range 10 – 15.
$\delta_{c/s}$	Compressive strength or shear strength in kPa denoted by "c" or "s". Compressive strengths are normally about 3 times the flexural strength value at the time, and shear strengths are about 1 to 1.2.
Rhoi	Density in Mg/m^3 . For unbubbled ice should be in the range 0.92 – 0.95 and for bubbled CD ice in the range 0.85 – 0.90.

Check that all values are there. If more than one mechanical property was done at exactly the same time the program sometimes gets confused and not all information may get summarized. If you notice identical times when entering the data then change one by a minute. If there is a problem later then edit the .log file and change the real time (in hours and minutes) by a minute and the hours of warm-up (decimal hours) by 0.02. Check also for any asterisks (****) written in the summary and investigate. If they are associated with the standard deviation (+/-) then this is likely not a problem as it is trying to calculate the SD from only one value. However, if asterisks appear in any hours of warm up then it is probably related to incorrect times and/or dates. If the asterisks appear in the place of any values then there is a problem in that calculation.

2.11.2 Editing run descriptions and flexural strength values at run times

One can give a very brief description of the model runs in the available space in the lines at the bottom of the page giving the strengths at run times. Start the description one space in from the left hand margin otherwise the text will be missing the first letter in the print out. There is space for about nine characters so one can give descriptions like "Level Ice", "Presawn", "N. Qt. Pt", "Turn #1", "9/10 Pack", etc. Compare the calculated flexural strengths at run times values with those calculated from the Temper times. They usually differ slightly as they are calculated differently. The Temper program simply interpolates the values based on the fitted curve thus smoothing out any scatter. The Summary program does the same but also then calculates the difference between the interpolated value and the value of the beams closest in time then adds (or subtracts) the difference from that beam value. This results in a bending of the fitted curve towards individually measured locations that may not be typical of the whole sheet. If all the beam values follow the fitted curve closely then there is not much difference between the two methods. However, if there is a lot of scatter and particularly if, as some time happens, subsequent beam values turn out higher than previous values, then this will be reflected in the Summary program calculations, so it possible to see a jump up in flexural strength values for later runs. This is counter-intuitive so as standard practice edit the Sum calculations with those from the Temper program.

Try and keep a nice format on the .mps sheet. If the preliminary print out has a page break separating the headings of the run descriptions from the rest, then enter a few more spaces so it starts on a fresh page.

2.11.3 Writing summary information to Datatrieve

When one is satisfied that all is correct in the .mps and .log file, Sum can be re-run in order to write the correct information into Datatrieve. If unsure of the correctness of the data, ask the Ice Tank Supervisor to check it out first. Re-running the program creates a new version of the .mps file and since the calculated strengths at run times at the end of the program are not stored in the database, rather than re-type or re-edit the changes, this time say "N" to calculating strengths. Since a new version of the .mps file is created the version that one did do edits on is now the previous version. So, now do a DIR TEST_DIR:TESTNAME.MPS command to see how many versions there are, then do a DEL TEST_DIR:TESTNAME.MPS;n command where n is the number of the last version. If you have delete/confirm command written into your login.com file (which you should have to help avoid accidental deletions) then the prompt should come back with confirmation of the file name and version before deletion. This will now leave your edited run version as the top version. Of course, there are other ways of running the datatrieve versions and editing the runs but the goals are to write correct information to the database and to leave your edited and final version of the .mps file as the top version. The "Purge" command (see Section 6 below) will get rid of all earlier versions.

2.12 Creating the Ice Sheet Summary SEED (RUN ICE_ANALYSIS$:ICE_SHEET)

This is the program which creates the text .iss (**i**ce **s**heet **s**ummary) file. A print out of this forms the cover sheet for the final summary document and summarizes the physical descriptions of the ice sheet as opposed to the mechanical properties. In preparation for running this program one will need to have already calculated the average ice tank water temperature, analyzed the ice tank temperatures .CZ file (see Section 3), and have at hand (for ease of finding numbers) print outs of the .thk file and the final .mps file. The program obtains some information from the header on the .log file and prompts the user for the remainder. The program prompts should be followed carefully to avoid potential problems. The target strengths and thickness are those given in the Ice Tank Schedule. The initial and final ice thickness are obtained from the calculated averages in the .thk sheet, and their associated hours of warm-up for each of them (not to be confused with the actual time) are obtained from the .mps sheet. Normally, one will accept the option to "input details of the freeze".

If a mistake is entered, the program can be halted with a Cntrl C or a No response to the write to Datatrieve option at the end of the program, then re-run the program entering the data correctly. The information is then written to the ice_sheet domain of the database and is very useful in determining freeze times and temper times for future ice sheets. One very useful parameter, but one that is rarely measured as it often happens in the middle of the night, is the ice thickness measurement at the start of warm up. Parts of the algorithms used in the mathematical model for calculating freeze times, temper times and final ice thickness estimate how much the ice grows during the hours of warm up. Since this is based on a few rare measurements, any further data would be of value in updating the equations.

2.13 Predict freeze and temper times for an ice sheet. PREDICT (RUN ICE_ANALYSIS$:COMPUTE_ICE_SHEET.EXE)

This program is part of the ice analysis suite of programs and although is not required for analysis during the testing is a useful tool in estimating times for scheduling an ice sheet. It utilizes mathematical models based on freezing and tempering times for approximately the first 500 <u>unbubbled</u> ice sheets. Consequently, extra allowance should be made for tempering times in bubbled (correct density) ice sheets. Even for unbubbled sheets, times should be confirmed by comparing with more recent data.

The program is simple to run requiring only the target thickness, strength and freezing temperature of the ice sheet (normally in the range –18° to –22°C) and returns the required FDH (Freeze Degree Hours, where 1 hour at –20° or 20 hours at -1° equals 20 FDH), the time for freezing and tempering and the expected initial ice thickness at the start of warm-up.

3.0 ANALYSIS OF THE .CZ FILE

The .CZ (control zone) file is an ASCII file of the temperature and FDHs recorded by the refrigeration PC from each of the 12 control thermocouples in the ice tank every five minutes (time selectable) together with the real time and the time since start of file. The format of the real time is in hours, minutes and seconds, while the time since start of file is in decimal hours which is convenient for calculating time intervals. The average temperature and FDHs from all the thermocouples are also shown.

The file contains the raw data necessary for the Ice Sheet Summary. It is necessary to identify the key elements of the freeze cycle, basically how long it froze for and at what temperature, and how long it tempered and at what temperature. To help identify the main elements use the printed form "Freeze Cycle Summary for Ice Sheet:----".

3.1 Instructions for Summarizing the Data in the CZ File

- Obtain the .cz file from the network PC (check with computer systems for current PC) and import it into Excel by:
- Selecting file, open, from the main menu and a Text Import dialogue box will open.
- Select Fixed Width and click next to see the column breaks. Most times they will be in the correct place. Sometimes with computer glitches, and in very long freezes when the FDH's exceed 999 some column shifting will take place and some manipulation may be required.
- Adjust column breaks if necessary then click Next then Finish and the file will be imported.
- Delete the lines (normally two) above the main column headings of "Time", "Hours", "avTMP" etc, so that line of headers is now the first row.
- The first value in the "avTMP" in Column C is normally "****". Looking at the first two legitimate values in the column extrapolate what the first value would have been and replace the asterisks with that value.
- Scroll down the spreadsheet looking at the average temperature. This temperature should fall to a first minimum coinciding with the time at which the seeding of the ice sheet started. This time should be within a few minutes of the time given in the Seed Description form. If not, the reason should be identified, for instance, the refrigeration computer has sometimes been set 12 hours out of sync. Note the cell number, temperature, real time and spent time on the form.
- Identify the end of the seed and note the numbers on the form. The end of the seed is normally about half an hour after the start of the seed at the next maximum temperature. This is at the point when the fans are turned back on and is the start of the freeze. Verify that the FDH's have been reset to zero at this time (more or less). If not, then the current value will have to be subtracted from the End of Freeze value. The average temperature between now and the End of Freeze (Start of Warm-up) is the Average Freeze Temperature (AFT)
- Identify when the target temperature is reached (normally within 0.2° is close enough) and note on the form. The target freeze temperature is identified in the

Ice Tank Schedule and is normally in the range -18° - -22°C. The average temperature between now and the End of Freeze (Start of Warm-up) is the Average Plateau Temperature (APT) and demonstrates how well the refrigeration plant was able to achieve the target temperature.

- Identify the End of Freeze (Start of Warm-up) and note on form. This time should be close to the estimated time in the Ice Tank Schedule. Also, note on the form the average FDH value and the FDH values for each of the 12 thermocouples. The latter values are required for comparison with ice thickness in the channel thickness profiles (see Section 7.3 below).
- Identify when the temperature first rises through 0°C and note on the form. This should be approximately 4 hours from Start of Warm-up.
- Identify the End of Warm-up and note on form. This is when the thermocouples are raised to the ceiling and the recorded temperatures are no longer meaningful. For the typical sheet this is about 08:15 hrs. at the start of the days activities. Usually a small rise in average temperature is seen in the record but if difficult to detect, looking at the individual thermocouple temperature values may give a better indication. The average temperature between rising through zero till now is the Average Tempering Temperature (ATT).
- Identify the End of File which is normally at the end of the day's activities and note on form. Sometime, the temperature logging continues for hours or even days after, in which case delete all unnecessary lines.
- Now perform the calculations for average temperatures. At the bottom of the data in the Excel sheet in the B column in cells one below the other enter "AFT", "APT" then "ATT" (for Average Freeze Temperature, Average Plateau Temperature, and Average Tempering Temperature.
- In the C cell adjacent to the AFT calculate the average temperature from the End of Seed to End of Freeze using the cell numbers you identified on the form using the formula: @average(C_{EOS}:C_{EOF})
- In the C cell adjacent to the APT calculate the average temperature from the Target Temperature to End of Freeze using the cell numbers you identified on the form using the formula: @average(C_{TT}:C_{EOF})
- In the C cell adjacent to the ATT calculate the average temperature from the Target Temperature to End of Freeze using the cell numbers you identified on the form using the formula: @average($C_{reach\ 0°}$:C_{EOWu})
- Format these three values to one decimal place and copy to the printed form.

3.2 Instructions for plotting graph of temperature

- From the main menu in Excel select "Insert", "Chart", "Line", then the first chart type option and select "Next".
- Select "Data Range", "columns" and in the box type: A1:A_{EOF},C1:C_{EOF} (where $_{EOF}$ is the last cell number). A miniature plot should appear and if all appears correct click "next".
- Under "Titles", enter Ice Sheet name (eg. KALVIK 1) for Chart Title, **Hours of Warm-up** for "Category (x) axis" and **Temperature (°C)** [hold down the Alt key and press 2 4 8 on the numeric keypad to make the symbol °] for "Value (y) axis".

- Select “Legend” from menu in box and click off “Show Legend” button then click “next”.
- Click “As new sheet” button, then “Finish”.
- Click with right hand button of mouse on background and select “Format Plot Area” from menu and click “None” under “Area” then OK to turn grey to white.
- Click on the x axis to highlight then right click and select “Format Axis”.
- Select “Scale” and for “Number of Categories between tick-mark labels” enter 24, and also 24 in ““Number of Categories between tick-marks”.
- Select “Number” and then select the first style on the list which is just hours and minutes.
- Select “Alignment” and drag horizontal line in window up to vertical, then click “OK”.
- Type and place the values for the Average Freeze Temperature, Average Plateau Temperature, and Average Tempering Temperature on the chart.
- Print out two copies of chart. One goes in the file (not normally included as part of the Final Summary Document”) and one goes to Refrigeration as it is a convenient way for the operators to see how well the plant achieved and maintained the temperatures.
- Save the file as an Excel Workbook in the project directory on ice$ directory (see also Section 7.1).

4.0 DELETING POINTS

Most of the analysis programs offer the option of deleting individual mechanical property values before calculating the average. Several of the tests that are done such as flexural strength, elastic modulus, shear and compressive strengths are prone to experimental error, which is why as many as six or seven values are taken for one set of results. When there is a wide scatter in values it is often a dilemma in deciding what is due to experimental error and what is the natural variability of ice. On the one hand we don’t want to enter erroneous values to the database, and on the other we don’t want to deliberately bias the data. In the modulus experiment, the first one or two points tend to be suspect because the support stage on which the deadweights are placed has not yet settled down under the light weights. In the shear tests, any unconformity on the flat surface between the stage and the ice will lead to preliminary flexural failure. In compressive strength, any unconformity on the ends of the samples will lead to point loading and preliminary failure, and in beam tests, preliminary failure can occur if the beam is accidentally and invisibly cracked during preparation. Occasionally, tough spots are encountered in the ice sheet and beams from these areas sometimes give unusually high flexural strength values.

There are a couple of tests on suspect data one can do to help decide whether to keep a value or not:

1) Average the highest and lowest values and see if that number falls within the spread of the remaining values. If it does then keep all the values, if it doesn’t then consider deleting the data point that biases the average.

2) Subtract the lowest value from the next lowest, and subtract the second highest from the highest. If the difference is more or less the same in each case then there is no reason to throw out one value over the other. If the difference in one is much more than the difference in the other then toss the anomalous one out.

Erroneous values in shear and compressive tend to be low values. In modulus and flexural strength they can be either way.

Example:

Values:	28
	44
	38
	39

Using test 1) the average of the highest, 44, and the lowest, 28, is 36 which is lower than the other values. Using test 2) there is a difference in 10 from the lowest to the second lowest but only 5 for the second highest to the highest. So, there is reasonable justification for deleting the 28 value.

5.0 RUNNING THE VMS EDITOR

There are a number of different editors one can use on the VAX system. Selection is personnel preference but one of the easiest to use is EDIT/TPU (Text Processing Utility). Help about VMS functions can be accessed at any time by typing "help" at the VMS prompt, however help about how to use the editor itself can only be accessed from within the editor.

To start the editor, type EDIT/TPU [filename.extension] as in EDIT/TPU TEST_DIR:KALVIK1.PNT For most part, the editor is required only to delete lines or edit entries so this description only covers the basics, however, the editor does have many functions and these can be viewed by typing "Help" in the command line.

Basic functions:

Ctrl A toggles between insert and type-over
Ctrl H places cursor at beginning of line
Ctrl E places cursor at end of line

5.1 Editing Text

The default mode of the keyboard on entering the editor is insert mode. Use Ctrl A to change to type-over. Edit text as appropriate.

5.2 Deleting Lines

Use Ctrl H to place cursor at beginning of the first line you want to delete. To select text for deleting, press the "End" key and use the down arrow key to highlight the lines of text you want to delete. This is a toggle switch so to cancel selected lines press the "End" key again. Having highlighted the lines or the text you want to delete, press the “Delete” key. The selected text will be cut and is temporarily written into a buffer (clipboard). The deletion can be cancelled by pressing the “insert” key but the cursor has to be in the same place as before as it will insert the text wherever the cursor is. Thus the “delete” and “insert” key can be used for cutting and pasting. The contents of the buffer can be re-inserted as many times as the “insert” key is depressed but will be lost as soon as a new selection is made, or on exiting the editor.

5.3 Saving and Getting Files

The Command or “Do” key is the “-“ key on the numeric keypad on the right hand side of the keyboard. This brings up a command line at the bottom of the editor screen. Typing “help” on the command line will display a variety of topics.

Saving files can be accomplished in two or three different ways. If only the one file needs to be edited, then having done so, type “Exit” on the command line. The editor will be exited and a new version of the file created. A “Quit” command will exit the editor **without** saving a new version. If more than one file needs editing (as in the flexural strength example below) then type “write” on the command line then enter, and a new version will be created. The command to open a new file is “get”. In fact, this command was invisibly used with the original edit/tpu command. By pressing the “do” key to bring up the command line then previous commands can be recalled by using the up arrow key, and if this is done then the original “get filename” will be recalled. The file extension (.pnt) can then be changed to .flx, and so on. Should you want to save with a new file name then type “write” and the name of the new file, and then execute.

5.3.1 Example

As an example, assume there were mistakes in the beam values when using the FLEX program on ice sheet Kalvik1. That means three files have to be corrected with the filename extensions .flx, .pnt, and .log.

- EDIT/TPU TEST_DIR:KALVIK1.FLX   (calls up the editor and file)
- Select and remove false entries using the “End” and “Delete” keys
- Press “DO” key and type “write”, then enter. (next version of TEST_DIR:KALVIK1.FLX is written)
- Press “DO” key again and hit up-arrow twice to display GET TEST_DIR:KALVIK.FLX
- Press Ctrl E to get to end of line and change the .FLX extension to .PNT and enter.
- Make the necessary changes to the .pnt file, hit the “DO” key and the hit the up-arrow to recall the “write” command and enter.   (next version of the .pnt file is written).
- Press the “DO” key again, and then the up-arrow twice to recall the last “GET” command and change the file extension to .LOG and enter.

- Delete the appropriate lines in the .log file, then press the “DO” key and type “exit”. The editor will be exited while automatically writing a new version of the log file.

Some other useful commands to know are:

- Bot (will take to the bottom of the file)
- Top (will take to the top of file)
- Two (will split screen – can then call up another file and cut and paste between the two windows using the command “other” to go from file in one window to file on the other)

5.4 Creating New Files

New VMS files can be created by using the “edit/tpu [newfilename]” command or within the editor by using the “get [newfilename]” command. It could be useful in creating temporary files. Also, one cannot have two versions of the same file open at the same time should one want to copy and paste information between the two. An example of this might be KALVIK1.MPS;1 and KALVIK1.MPS;2. The edit/tpu command will always take the latest version if unspecified, so to open the first version the command would have to be EDIT/TPU TEST_DIR:KALVIK1.MPS;1. However, once open, the mps;2 version cannot be opened at the same time. If required, the VMS command RENAME can be used at the $ prompt using the explicit version number of the file to change a name.

6.0 PURGING FILES

Every time a VMS file is edited and saved a new version is created. The list of files can be viewed by using the Directory command as in DIR Test_Dir:Kalvik*, using * as a wild card to view a list of all Kalvik files, for instance, or specifically DIR Test_Dir:Kalvik1.flx to see a list of all versions of the flex files. To avoid disk space problems there is an automatic purging every night which leaves the three most recent versions. At the conclusion of each project, once all summaries have been satisfactorily produced, then use the purge command to clean up the remainder of the files; i.e. PU TEST_DIR and this will delete all but the most recent version.

7.0 CREATING TEMPERING CURVES AND CHANNEL THICKNESS PROFILES

7.1 Copying the VMS Files to the PC Network for Analysis and Storage

When plotting or other analysis of the data is required the user will often find it best to copy to a PC based software such as Excel. The VMS and PC network are two separate systems but the VMS directories can be linked to the PC. Methods of doing this vary so the user should consult with the appropriate computer support group for the best way of doing this at the time. Permanent storage for Ice Tank PC system based files such as the

Excel sheets is set up on an Ice$ folder (\\knarr\ice$ at the time of writing) on the PC network.

To simplify transferring of files to the Ice$ directory a drive can be mapped to your PC as follows (this will only have to be done once or when there are system or PC changes):

- go into Explorer and click on Tools on the main bar and select Map Network Drive.
- Select an available network drive (I for Ice?) and type \\knarr\ice$ and select "reconnect at login" then finish. Drive I will now act like C or M.

An appropriate project folder in the Ice$ directory should be created for each project.

7.2 Creating the Tempering Curve

The tempering curve is created from the flexural strength data in the .pnt file but first it is necessary to get all the x and y data (time and beam strength values) together. Every time the flex program is run it creates headers in lines of zeros and text in the .pnt file. In order to get all the x and y points of the beam data together it is necessary to delete all these extra lines of headers. This can be done using the editor in VMS, or if one prefers in Excel as outline below.

To create the tempering curve:

- Open Excel and by using File, Open (other files), select the .pnt file to import
- Select the Fixed Width option in the Text Import Wizard dialogue box, then Next
- Move or create new break lines to put the x and y data into adjacent columns, remembering that thickness data (usually in lines below) can be captured in the columns at the same time (see 7.3 Creating the Ice Thickness Profile), then Finish
- Delete rows or cut and paste as necessary to get all the beam data in consecutive rows
- Select the two columns of beam data and use Insert, Chart, and select X-Y (Scatter), then Next to display the plot
- From the Titles menu use this suggested format in same case and bold characters:
    - Chart Title: **KALVIK 1 TEMPERING CURVE**
    - Value X axis: **Hours of Warm-up**
    - Value Y axis: **Flexural Strength (kPa)**
- From the Legend menu unclick Show Legend, then Next and select As New Sheet, then finish
- Change background colour to "None" in "Format Plot Area" by right clicking on graph area.
- Choose X and Y scales to make the plot look balanced. The Flexural Strength should originate at 0 but if the tempering time is long the Hours of Warm-up may look better starting at some higher value.
- Save the files as an Excel sheet in the appropriate folder of the Ice$ directory
- Print off the chart to include in the final summary document.

7.3 The Ice Thickness Profile

Graphs of measured ice thickness from the sides of the channel cut through the ice by the model are prepared for each ice sheet. These profiles give a quick visual representation of ice thickness variation throughout the length of the tank, and when the center channel in particularl is compared with the profile of the Freeze Degree Hours (FDH) as recorded by each of the 12 thermocouples, variations in thickness may be seen to reflect variations in the FDH profile. Over a period of time trends may be identified and persistent anomalies in ice sheet thickness corrected by either adjusting the flow of ammonia to particular evaporators, or by altering the height of the control thermocouples over the ice.

Previously, the thermocouples were in a single line down the length of the tank. With the exception of #1 and #12 at each end of the tank which controlled the evaporators on each side of the thermocouple, the remainder controlled pairs of evaporators on one side. To try and even out the system, the thermocouples were paired up, as they are now, with the thermocouples closer to the pair of evaporators they actually control. The tank position of the thermocouples (given below) in plotting the FDH data still reflects this original positioning of the thermocouples.

7.3.1 Creating the Ice Thickness Profile

The first step in preparing the profile is to analyze the .CZ file and fill out the "Freeze Cycle Summary for Ice Sheet:---" form (Section 3 above) in order to identify the FDHs for each thermocouple at the end of the active freeze cycle.

The corresponding tank position for each of the thermocouples is:

#1	2 meters
#2	10
#3	16
#4	22
#5	29
#6	36
#7	44
#8	52
#9	59
#10	66
#11	73
#12	80 meters

The next step is then to prepare two columns of data in the Excel sheet of the original .pnt data (see the first part of the instructions of 7.2 above) with the Thermocouple Tank Position as X data and the corresponding FDH value for each thermocouple as the Y data. Excel has a few quirks so for now only have a heading "Position" in the X data in the cell immediately above the first number.

Type “Thickness” in the cell immediately above the column of thickness values you want to plot. Now:

- With the cursor select the two columns of position and thickness data including the line immediately above the data.
- From the main menu choose “Insert”, “Chart”, “XY (Scatter)”, chart type “Scatter with data points connected by lines” then “Next”.
- Make sure Columns button is selected and plot looks OK , then choose “Next”.
- Using same format, case and bold characters,
    - in Chart Title enter **KALVIK 1 ICE THICKNESS PROFILE**
    - in Value (x) axis enter **Tank Position (m)**
    - in Value (y) axis enter **Ice Thickness (mm)**
- Click “Next”, choose “As new sheet” and click Finish.
- Right click to get menu and select “None” in “Format Plot Area” to clear grey colour.
- From Main menu select “Chart” then “Add Data” and a “Range” box will open.
- Click on the appropriate Sheet label at the bottom of the screen, then highlight the two columns of position and FDH data including the header row
- Click OK on the dialogue box and another Paste Special dialogue box will open.
- Select “New Series”, “Columns”, “Series Names in first row”, “Categories (x values) in first column” and click OK.
- Both plots will now appear but on the left hand X axis. Click on new FDH line on graph to highlight markers, then right click and choose “Format Data Series” then “Axis”, then select “Secondary Axis”, then click OK and FDH plot will use the right hand axis.
- Right hand click on the chart background and choose “Chart Options” from the box, then Titles and type “**FDH**” in the “Second Value (y) Axis” title box and click OK.
- Go back to the data sheet and enter FDH in cell immediately above FDH data.
- FDH will now appear in legend box in graph. Drag box into convenient place on graph and widen plot by clicking on border and dragging out corner.
- To improve the scaling if necessary, click on the appropriate left or right hand axis, then right hand click on the mouse, choose “format axis”, then “scale” and enter new maximum and/or minimum values.
- As required, prepare a graph for the South and/or North channels with appropriate titles but do not replot the FDH data.
- Save the file as an Excel Workbook, and print out a copy of the graph which will form part of the final summary document.

8.0 SUMMARY SHEETS AND FILE STORAGE

The final summary document should include:

Ice sheet summary (ISS) as cover sheet
Mechanical property sheet(s) (MPS)
Chart of tempering curve
Chart of ice thickness profile

Ice Sheet Properties and Location Diagram (if used)

Prepare a copy each for the files, the project manager and the client.

The raw data sheets and print outs of the mechanical properties should be kept in a cardboard file folder and stored in the filing cabinet in sequential order with the other ice sheets. Label the folder with the Ice Sheet Name, number, target strength and thickness. This folder will likely outlast any digitally stored information so make sure it includes:

- Final Summary Document
- Temperature chart
- Raw data forms:
    - Seeding description sheet
    - Beam sheets
    - Flexural Strength survey sheets
    - Modulus and density sheets
    - Compressive and shear strength sheets
    - Thickness sheets
    - Modulus chart
    - Friction chart
- Print outs of analysis programs: .flx, .fsc, .mod, .den, .cmp, .shr, .thk, .hif, and a print out of the Temper program if used.

9.0 OTHER RELEVENT DOCUMENTATION

Jones, S.J. (1993) Ice Tank Test Procedures at the Institute for Marine Dynamics. Institute for Marine Dynamics. LM-AVR-20.

IOT Standard 42-8595-S/GM-4: Environmental Modeling – Ice
    http://web.iot.nrc.ca/qa/Standards/Approved/GM4V2.doc

IOT Work Instruction TNK-23: Seeding the Ice Tank
    http://web.iot.nrc.ca/qa/WORKINST/Approved/TNK23_V1.doc

IOT Work Instruction TNK-25: Ice Thickness Measurement
    http://web.iot.nrc.ca/qa/WORKINST/Approved/TNK25_A1.doc

IOT Work Instruction TNK-26: Flexural Strength Measurement/Survey
    http://web.iot.nrc.ca/qa/WORKINST/Approved/TNK26_V1.doc

IOT Work Instruction TNK-27: Elastic Modulus Measurement
    http://web.iot.nrc.ca/qa/WORKINST/Approved/TNK27_V1.doc

IOT Work Instruction TNK-28: Compressive Strength Measurement
    http://web.iot.nrc.ca/qa/WORKINST/Approved/TNK28_V1.doc

IOT Work Instruction TNK-29: Shear Strength Measurement
    http://web.iot.nrc.ca/qa/WORKINST/Approved/TNK29_V1.doc

IOT Work Instruction TNK-30: Ice Density Measurement
    http://web.iot.nrc.ca/qa/WORKINST/Approved/TNK30_V1.doc

IOT Work Instruction TNK-32: Hull/Ice Friction Set-up & Measurement
    http://web.iot.nrc.ca/qa/WORKINST/Approved/TNK32_V1.doc

IOT Work Instruction TNK-37: Programming the Controllable Density Bubbler System
    http://web.iot.nrc.ca/qa/WORKINST/Approved/TNK37_V1.doc