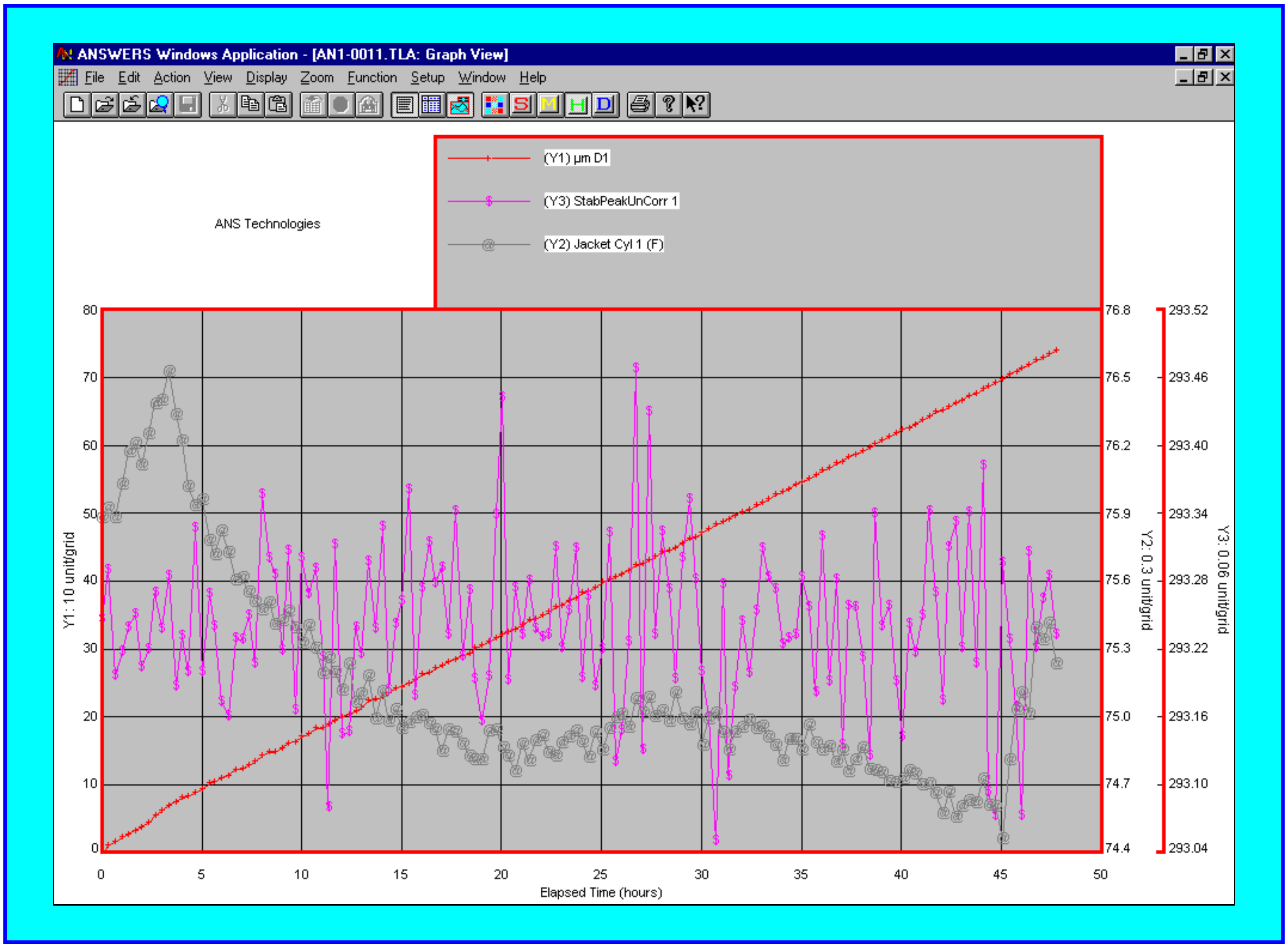
Les technologies ANS Technologies

Track-Wear

Real-Time Wear & Corrosion Monitoring Equipment



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Introduction

The Track-Wear system is a complete package of hardware and software products for the performance of Surface Layer Activation (SLA) studies. The technique is also known as Thin Layer Activation (TLA). The components of this system, which will be described in the following sections, are:

ANIQSpec Integrated Spectroscopy System
ANSWERS Multispectrumming Data Acquisition and Analysis Software
ANIQMCA Spectrum Acquisition and Analysis Software
IOViewer Data Acquisition Software
Support Equipment, including counting reservoirs, water jackets, lead shields and support stands

SLA is a technique for measuring wear or corrosion in real time. It is accomplished by monitoring the radiation emanating from either the radioactive surface from an eroding component, or radioactive debris in a lubrication circuit. By measuring the loss of radioactivity from the component, or the accumulation of radioactivity in the lubricant, the material loss can be precisely determined. The radiation is measured with gamma-ray detectors and processed by computer-controlled electronics.

ANIQSpec Integrated Spectroscopy System

Track-Wear is a Multi-Channel Analyzer spectroscopy system (MCA), which means that the gamma-rays are energy-analyzed to allow separation of the gamma-rays coming from different isotopes. A spectroscopy system begins with a detector. The detector is powered with an applied high-voltage, and its signals are sent through an amplifier, which also shapes the pulses. The amplified pulses are fed into an Analog-to-Digital Converter (ADC), which generates the digital signal suitable for computer control. Each time a gamma-ray hits the detector, its energy is determined, and this information is sent to an MCA, which is interfaced with the PC. Track-Wear is capable of using both NaI and Ge detectors.

The purpose of the MCA is to receive and store this data, and transfer it to the PC memory on command, along with the acquisition time. The board has a 4096-channel memory, and each channel represents a small energy interval. Each time a signal is received from the ADC (while the MCA is active), the contents of the appropriate channel is incremented by one. The MCA responds to commands from a software package, which include start/stop data acquisition, transfer data to the PC, and clear the memory of the MCA.

This system comprises six components and assorted cables and adapters. These components are:

ANIQVME:	VME Backplane Chassis, Model ANIQSpec-702
ANIQ USB-PPI:	Interface Module, Model ANIQ
ANIQMCA14:	Spectroscopy Module, Model ANIQSpec-503
ANIQHV:	High-Voltage Power Supply and Preamp Power Supply, Model ANIQSpec-501
ANIQIO:	I/O Module and Connection Block, Models ANIQSpec-600 & ANIQSpec-601

Figure 1 : ANIQSpec Integrated Spectroscopy System

Each of these modules will be described hereunder. With each Integrated Spectroscopy System, there will be one chassis and one Interface Module. There will also be one Spectroscopy Module and one ANIQHV for each detector channel ordered.

ANIQVME: VME Backplane Chassis, Model ANIQSpec-702

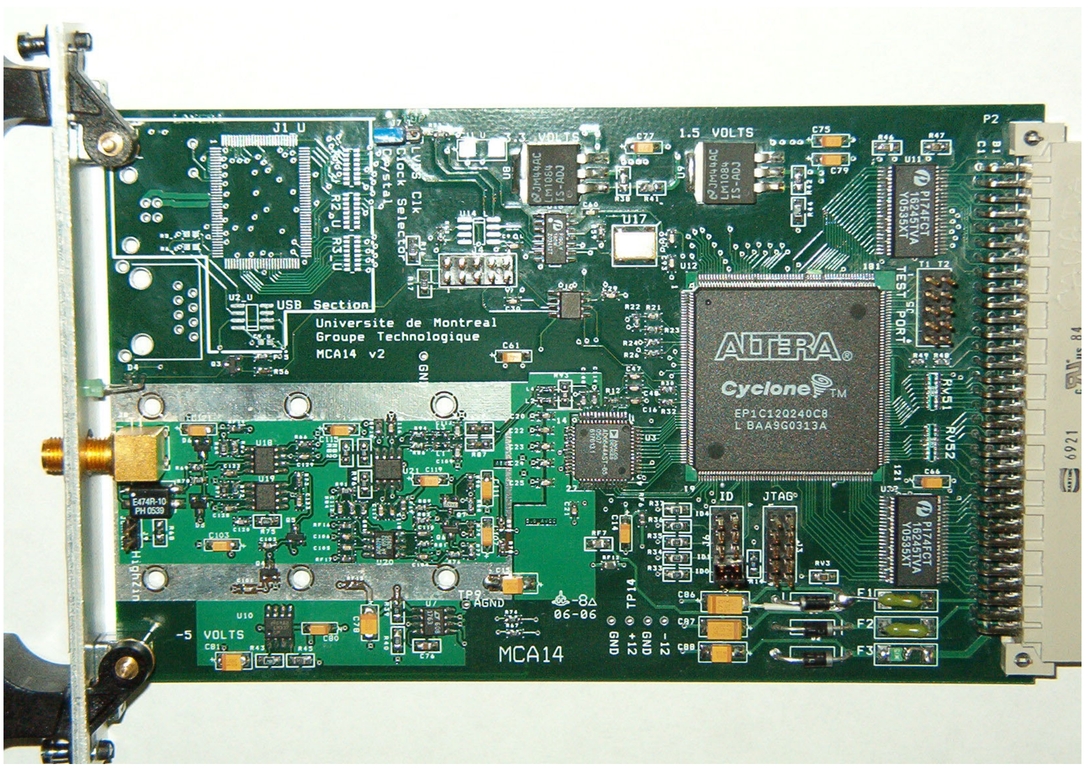
The ANIQVME Chassis was designed by ANS Technologies to provide the smallest possible chassis for the typical requirement, namely one- or two-detector-channels. It is equipped with five VME 3U slots, and a power supply with two switches. As each chassis is custom-made, the client can order up to ten VME slots. There is a VME connector at the back of each module that fits into the VME backplane of the chassis. The power supply is connected to the VME backplane. There are three outputs: +5 volts, +12 volts and -12 volts. The two switches on the front panel of the chassis interrupt the +5 and +12 volt lines.

ANIQ USB-PPI: Interface Module, Model ANIQSpec-801

The Interface Module provides the communication between the PC and the VME backplane of the chassis (and hence the other modules). It may be plugged into any slot, and connected to the parallel port of the PC by an IEEE-1284 compliant M-M cable (included). If the acquisition PC does not have a compliant parallel port, a plug-in adapter may be used, available for both desktop and laptop PCs.

ANIQMCA14: *Spectroscopy Module, Model ANIQSpec-503*
The ANIQMCA14 Spectroscopy Module is a combination amplifier, flash ADC and MCA. The user may either connect the output of either a NaI or a Ge detector to the amplifier input. This board, like the others in this package, is a half-height unit that fits a VME 3U Slot. It contains 32-bit memory and plugs into a VME-A24D16 3U backplane, mounted in a chassis. One ANIQMCA14 board is required for each detector, and each board has jumpers to set its ID number. This ID number is used by the software to reference the board. All the ANIQMCA14 boards installed in the chassis communicate via the backplane to the interface board. Thus, the software controls four utterly independent detectors (each detector has its own amplifier, ADC and 4096-channel on-board memory). The software packages can control all four boards simultaneously, and each board acquires data independent of the PC.

Figure 2 : ANIQMCA14 Spectroscopy Module



The operating parameters of the ANIQMCA14 are selected via software, and include the peaking time (for pulse shape analysis), the input polarity, the ADC gain and the LLD. For Ge detectors, the user may also set the pole zero correction and an additional pulse shaping parameter to compensate for variation in risetime as a function of energy. This gives the MCA14 excellent resolution for Ge detectors, limited only by the detector itself.

ANIQHV: *High-Voltage Power Supply and Preamp Power Supply, Model ANIQSpec-501*
This unit is powered by +12 volts and outputs 1 mA at +1000 volts. It is a highly stable, regulated power supply. The supply is mounted on a VME board and the circuit allows the user to conveniently apply power to NaI photomultipliers. The entire interface is on the front panel. The HV output is via an SHV connector, and is controlled from 0-1000 volts by a trim potentiometer labelled "Gain". There is a series of ten LEDs that illuminate from bottom to top as each step of 100 volts is passed. There is also a test point tuned so that one volt on the test point is 1000 volts HV output. The test point has

been provided so that voltages in between steps of 100 volts may be accurately applied, should the user desire to do so. A DB9 connector is provided to supply power to a standard NaI preamplifier that operates at 12 volts. These lines have inductive and capacitive filters to stop any noise from the VME backplane. This unit is also available with high voltages for Ge detectors.

ANIQIO: *I/O Module and Connection Block, Models ANIQSpec-600 & ANIQSpec-601*
The analog input section of the ANIQIO board may be used to read voltages from thermocouples, resistance temperature devices (PT100 RTDs) and other devices. There are 16 single-ended channels, which may also be configured in pairs for differential operation. The input may be configured as unipolar (max 40 volts) or bipolar (-20 to +20 volts max). The gain may be adjusted to yield a precision of better than 0.1 mV for thermocouples. The connection block is also equipped with a temperature sensor for cold junction compensation. Up to eight four-wire RTDs may be connected. The ANIQIO board provides an RTD reference current, and the ADC compensates so that the voltage reading is independent of the number of RTDs or the length of their lead wires.

There are also five analog output channels. These channels have 12-bit outputs that have been configured to give between 0 and 4.095 volts in increments of 1 mV.

Finally, the ANIQIO board is equipped with eight digital IO channels. In the output mode, each channel may be configured to give either a TTL voltage (3.33 volts), or act as a switch. This allows the use of either TTL or switch relays.

There is one jumper, which determines the board number. This allows the software to operate up to four ANIQIO boards in a single chassis. The rest of the configurations are done by software. A program called IOViewer is provided that controls all the features of one board on a single display. Multiple instances of IOViewer may be run to control up to four ANIQIO boards.

ANSWERS Multispectrumming Data Acquisition and Analysis Software

General Operation

ANSWERS is a sophisticated program that performs a multitude of control and analysis functions to perform SLA experiments. In a normal SLA experiment, a sequence of gamma-ray spectra is acquired during the operation of an engine or other machine. The machine contains a radioactive component from which gamma-rays are emitted. Each detector may be placed either opposite a radioactive component, or in the lubrication circuit of the machine. In the first case, called the Residual Method, wear or corrosion is monitored by deducing the loss of radioactivity from the component. In the second case, called the Flow-Through Method, wear is deduced by monitoring the accumulation of radioactive debris in the lubricant. Thus, each sequential spectrum from each detector is a measure of the accumulated wear or corrosion up to that point in time. Thus, the user inputs the acquisition time of each spectrum, based on the time frame of the wear or corrosion process. ANSWERS then controls the acquisition time of the detectors, and controls the transfer of this spectral data from each MCA at the end of each counting interval.

For each data point (which comes from a gamma-ray spectrum collected for a preset time interval), ANSWERS independently stores and analyses the spectrum from each detector *in real time* and displays the results in terms of wear or corrosion. The first step in the analysis is specific to the detector in question. The parameters include:

- Whether the Residual or Flow-Through Mode is being employed for that detector.
- The energy calibration for the detector.
- The gamma-ray peak to be used for the gain stabilization system.
- The number of channels in the spectrum.

The second step in the analysis involves the selection and identification of the regions (ROIs) of the spectrum from which wear is to be deduced. Several ROIs of *each* spectrum may be analyzed independently, thus permitting one to measure the wear of adjacent components activated with different isotopes. Each ROI is analyzed according to its own input parameters, which include:

- The range of gamma-ray energy for the region.
- If the region is a single gamma peak, the number of channels on either side of the peak used to subtract the Compton background. If this parameter is zero, the region is treated as an interval with no background subtraction.
- The units in which the data (wear or counts) is to be expressed (microns, mg/cm^2, etc.).
- The isotope in the ROI, including the gamma-intensity and half-life.
- The concentration of the isotope as a function of depth in the sample, or "Activation Profile".
- The detector from which the data is taken and its efficiency.
- The date of activation and amount of radioactivity in the piece at that time.

One analysis according the above set of parameters is called a *series*, and the result of an analysis is a single number or *data point* for each counting interval. Up to 100 series may be analysed at the end of each interval. Thus the data set comprises a matrix of rows and columns, where each column is a series, and each row is a counting interval. There are three additional columns, being the Date/Time of the interval, the Elapsed Time since the start of the run, and a Data Point/Spectrum Number. The analysis of the data takes from 70 to 300 milliseconds at the end of each interval. The series data is continually updated which allows the user to monitor *on-line* the evolution of wear or corrosion from a number of components simultaneously.

Besides series extracted from the MCA data, ANSWERS is also equipped to control and analyse data from our ANIQIO board. This data would normally include operating parameters of the machine itself, such as temperatures, pressures or speeds. The ANIQIO is capable of handling up to 16 analog inputs, 5 analog outputs and 8 digital IO channels. The user may define series as coming from the ANIQIO board in addition to those from the ANIQSpec2 boards.

In addition to the analysed data set, the individual raw spectra are stored. This permits the user to perform a *Re-analysis* of the gamma data after the fact. Thus, if the user discovers some error in the analysis parameters, or simply wishes to see the effect of different analysis parameters, it is not necessary to redo the experiment. The user merely makes the desired modifications to the input, and runs the automatic re-analysis procedure.

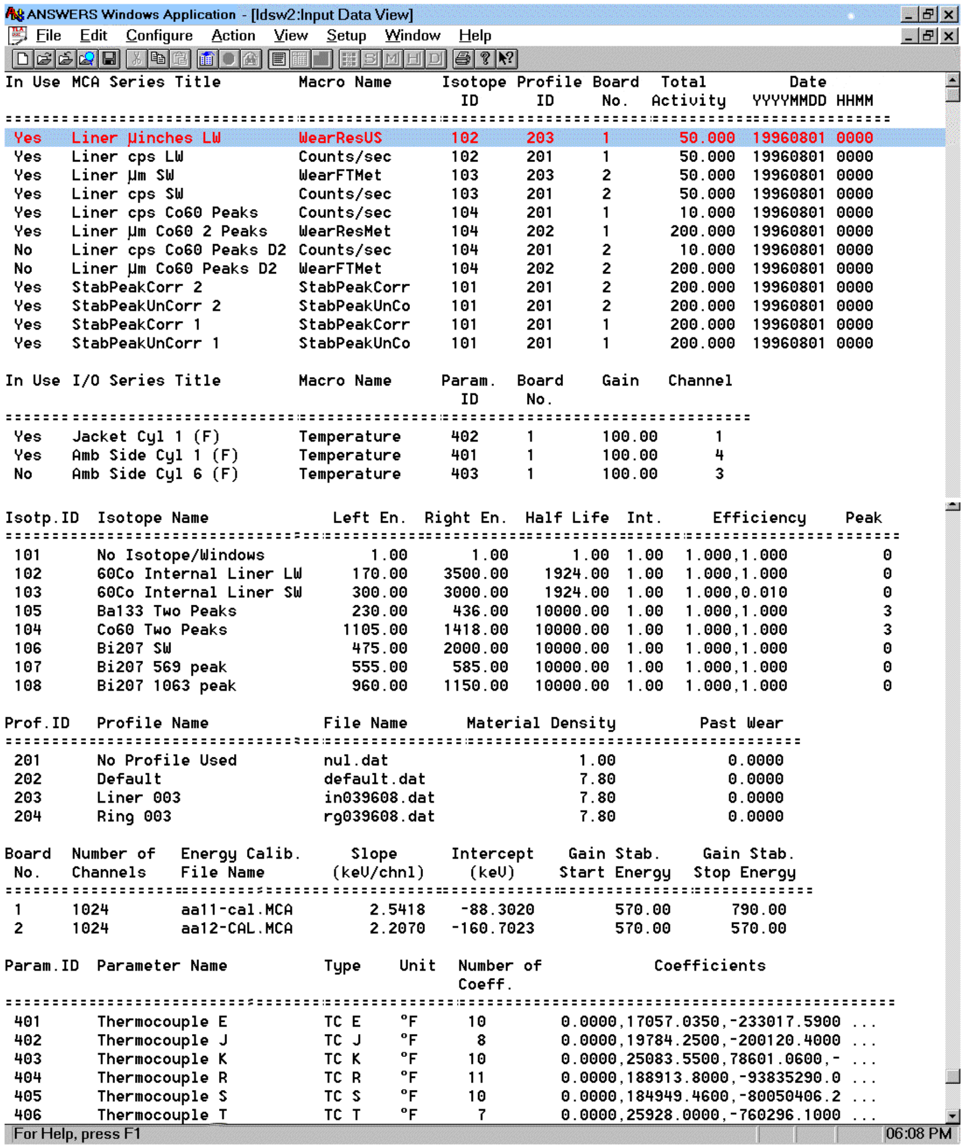
Gain Stabilization

Because NaI detectors are subject to gain shifts (due mostly to varying temperature), steps must be taken to correct this effect. Often, one cools the NaI detectors in cases where they are exposed to much heat. ANSWERS is equipped with a Gain Stabilization Routine which follows the position of a peak in each spectrum, from point-to-point, and re-organizes the data on-line to correct for this effect. When using the Flow-Through Method, there is often no convenient peak at the start of the test. The detector may be equipped with an artificial peak at the end of the spectrum for this purpose. If one has any intention at all of doing Flow-Through measurements (oil reservoir or filter), the Internal Detector Reference Pulser is recommended. It can only be installed when the detector is manufactured.

The ANSWERS Database: Input View

Each experiment/analysis is stored in a single file, with a .TLA extension. This file contains all the input and output data, and is accessed by the ANSWERS Windows interface. There are three “views” of the data: the Input View, the Data View and the Graph View. The Input View, which has six sections, is shown in Figure 3.

Figure 3 : Input View



ANSWERS Windows Application - [ldsw2:Input Data View]

File Edit Configure Action View Setup Window Help

In Use	MCA Series Title	Macro Name	Isotope ID	Profile ID	Board No.	Total Activity	Date YYYYMMDD HHMM
Yes	Liner µinches LW	WearResUS	102	203	1	50.000	19960801 0000
Yes	Liner cps LW	Counts/sec	102	201	1	50.000	19960801 0000
Yes	Liner µm SW	WearFTMet	103	203	2	50.000	19960801 0000
Yes	Liner cps SW	Counts/sec	103	201	2	50.000	19960801 0000
Yes	Liner cps Co60 Peaks	Counts/sec	104	201	1	10.000	19960801 0000
Yes	Liner µm Co60 2 Peaks	WearResMet	104	202	1	200.000	19960801 0000
No	Liner cps Co60 Peaks D2	Counts/sec	104	201	2	10.000	19960801 0000
No	Liner µm Co60 Peaks D2	WearFTMet	104	202	2	200.000	19960801 0000
Yes	StabPeakCorr 2	StabPeakCorr	101	201	2	200.000	19960801 0000
Yes	StabPeakUnCorr 2	StabPeakUnCo	101	201	2	200.000	19960801 0000
Yes	StabPeakCorr 1	StabPeakCorr	101	201	1	200.000	19960801 0000
Yes	StabPeakUnCorr 1	StabPeakUnCo	101	201	1	200.000	19960801 0000

In Use	I/O Series Title	Macro Name	Param. ID	Board No.	Gain	Channel
Yes	Jacket Cyl 1 (F)	Temperature	402	1	100.00	1
Yes	Amb Side Cyl 1 (F)	Temperature	401	1	100.00	4
No	Amb Side Cyl 6 (F)	Temperature	403	1	100.00	3

Isotp.ID	Isotope Name	Left En.	Right En.	Half Life	Int.	Efficiency	Peak
101	No Isotope/Windows	1.00	1.00	1.00	1.00	1.000,1.000	0
102	60Co Internal Liner LW	170.00	3500.00	1924.00	1.00	1.000,1.000	0
103	60Co Internal Liner SW	300.00	3000.00	1924.00	1.00	1.000,0.010	0
105	Ba133 Two Peaks	230.00	436.00	10000.00	1.00	1.000,1.000	3
104	Co60 Two Peaks	1105.00	1418.00	10000.00	1.00	1.000,1.000	3
106	Bi207 SW	475.00	2000.00	10000.00	1.00	1.000,1.000	0
107	Bi207 569 peak	555.00	585.00	10000.00	1.00	1.000,1.000	0
108	Bi207 1063 peak	960.00	1150.00	10000.00	1.00	1.000,1.000	0

Prof.ID	Profile Name	File Name	Material Density	Past Wear
201	No Profile Used	nul.dat	1.00	0.0000
202	Default	default.dat	7.80	0.0000
203	Liner 003	in039608.dat	7.80	0.0000
204	Ring 003	rg039608.dat	7.80	0.0000

Board No.	Number of Channels	Energy Calib. File Name	Slope (keV/chnl)	Intercept (keV)	Gain Stab. Start Energy	Gain Stab. Stop Energy
1	1024	aa11-cal.MCA	2.5418	-88.3020	570.00	790.00
2	1024	aa12-CAL.MCA	2.2070	-160.7023	570.00	570.00

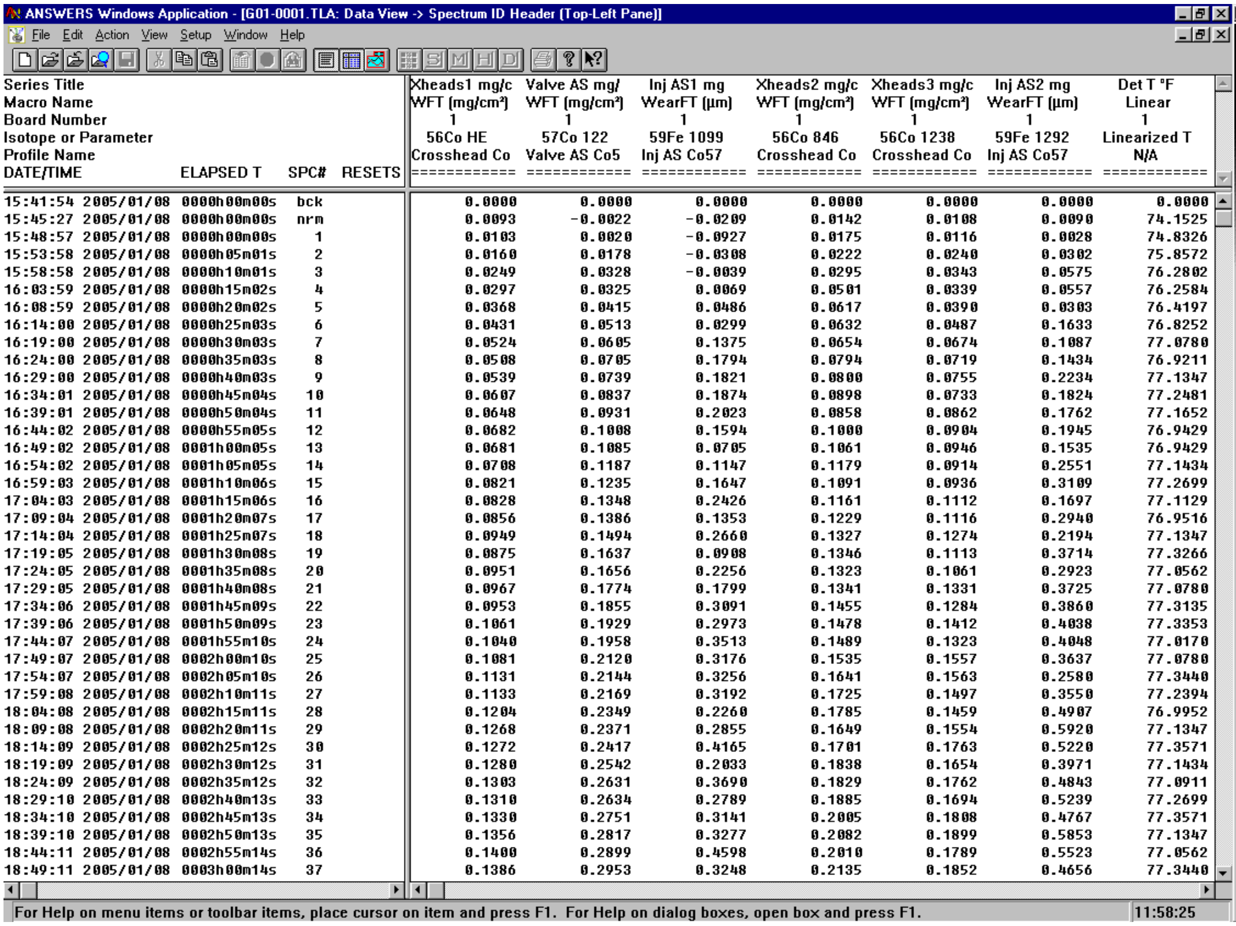
Param.ID	Parameter Name	Type	Unit	Number of Coeff.	Coefficients
401	Thermocouple E	TC E	°F	10	0.0000,17057.0350,-233017.5900 ...
402	Thermocouple J	TC J	°F	8	0.0000,19784.2500,-200120.4000 ...
403	Thermocouple K	TC K	°F	10	0.0000,25083.5500,78601.0600,- ...
404	Thermocouple R	TC R	°F	11	0.0000,188913.8000,-93835290.0 ...
405	Thermocouple S	TC S	°F	10	0.0000,184949.4600,-80050406.2 ...
406	Thermocouple T	TC T	°F	7	0.0000,25928.0000,-760296.1000 ...

For Help, press F1 06:08 PM

The first two sections of the list are the series that will be extracted from the raw data: the first section is the list of series deduced from gamma-ray spectra (MCA), while the second is the list of series extracted from the ANIQIO board. The last four sections are parameter sets to which the series input entries refer. The MCA series refer to the first three of these sections (Isotope, Profile, and Board), while the ANIQIO series refer to the last section (Parameters). On the Input View, these references are made by an ID number, with the exception of the Board section, where the reference is made by Board Number.

Each section has a list of entries (an entry being a line). In each section, the user may add new entries to the end of the list, insert entries in the middle of the list, edit entries already in the list, or delete entries. To accomplish these operations, the user first highlights one entry in one section. This may be an entry he wishes to modify, or one to use as a starting point for the creation of a new entry. A dialog box is then displayed for the user to modify.

Figure 4 : Data View



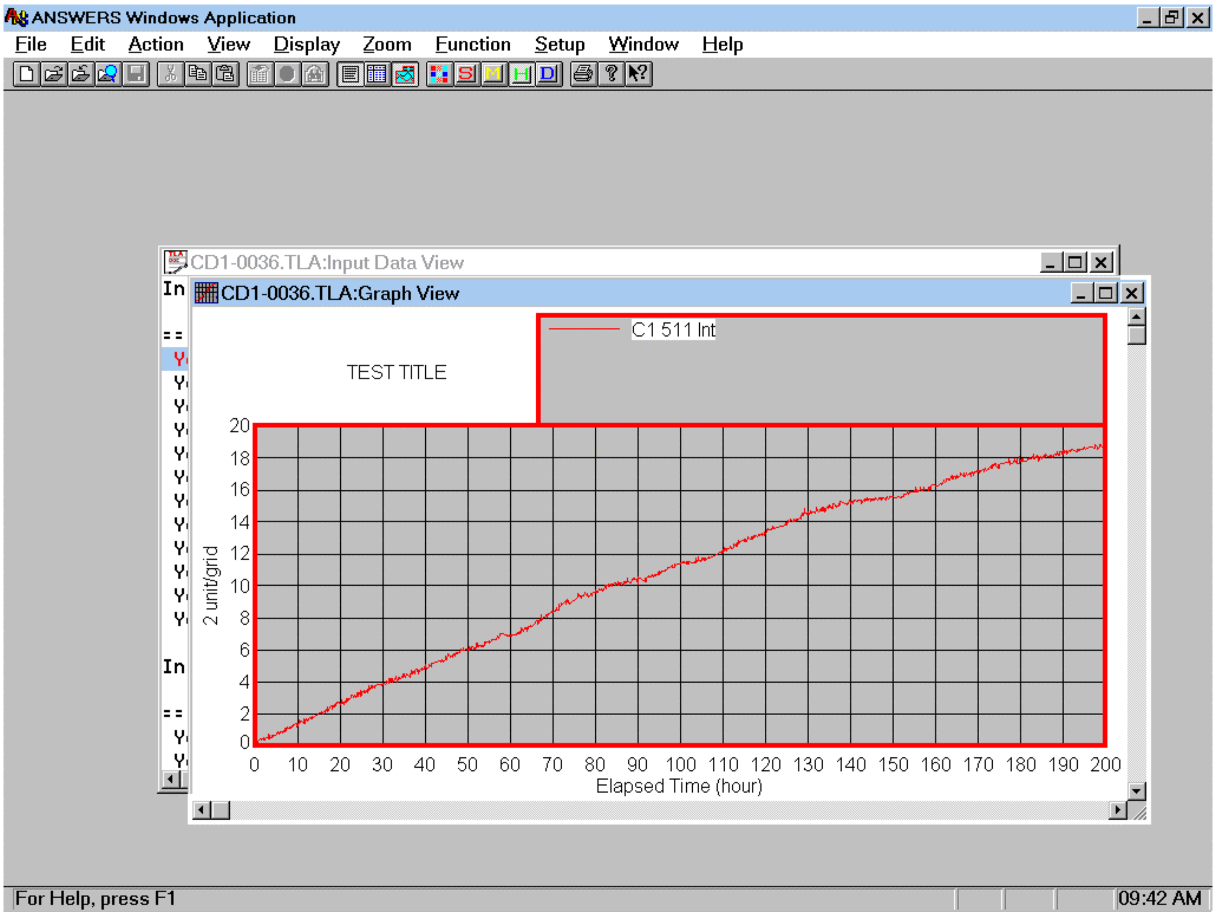
Series Title				Xheads1 mg/c	Valve AS mg/	Inj AS1 mg	Xheads2 mg/c	Xheads3 mg/c	Inj AS2 mg	Det T °F
Macro Name				WFT (mg/cm²)	WFT (mg/cm²)	WearFT (µm)	WFT (mg/cm²)	WFT (mg/cm²)	WearFT (µm)	Linear
Board Number				1	1	1	1	1	1	1
Isotope or Parameter				56Co HE	57Co 122	59Fe 1099	56Co 846	56Co 1238	59Fe 1292	Linearized T
Profile Name				Crosshead Co	Valve AS Co5	Inj AS Co57	Crosshead Co	Crosshead Co	Inj AS Co57	N/A
DATE/TIME	ELAPSED T	SPC#	RESETS	============	============	============	============	============	============	============
15:41:54 2005/01/08	0000h00m00s	bck		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15:45:27 2005/01/08	0000h00m00s	nrm		0.0093	-0.0022	-0.0209	0.0142	0.0108	0.0090	74.1525
15:48:57 2005/01/08	0000h00m00s	1		0.0103	0.0020	-0.0927	0.0175	0.0116	0.0028	74.8326
15:53:58 2005/01/08	0000h05m01s	2		0.0160	0.0178	-0.0308	0.0222	0.0240	0.0302	75.8572
15:58:58 2005/01/08	0000h10m01s	3		0.0249	0.0328	-0.0039	0.0295	0.0343	0.0575	76.2802
16:03:59 2005/01/08	0000h15m02s	4		0.0297	0.0325	0.0069	0.0501	0.0339	0.0557	76.2584
16:08:59 2005/01/08	0000h20m02s	5		0.0368	0.0415	0.0486	0.0617	0.0390	0.0303	76.4197
16:14:00 2005/01/08	0000h25m03s	6		0.0431	0.0513	0.0299	0.0632	0.0487	0.1633	76.8252
16:19:00 2005/01/08	0000h30m03s	7		0.0524	0.0605	0.1375	0.0654	0.0674	0.1087	77.0780
16:24:00 2005/01/08	0000h35m03s	8		0.0508	0.0705	0.1794	0.0794	0.0719	0.1434	76.9211
16:29:00 2005/01/08	0000h40m03s	9		0.0539	0.0739	0.1821	0.0800	0.0755	0.2234	77.1347
16:34:01 2005/01/08	0000h45m04s	10		0.0607	0.0837	0.1874	0.0898	0.0733	0.1824	77.2481
16:39:01 2005/01/08	0000h50m04s	11		0.0648	0.0931	0.2023	0.0858	0.0862	0.1762	77.1652
16:44:02 2005/01/08	0000h55m05s	12		0.0682	0.1008	0.1594	0.1000	0.0904	0.1945	76.9429
16:49:02 2005/01/08	0001h00m05s	13		0.0681	0.1085	0.0705	0.1061	0.0946	0.1535	76.9429
16:54:02 2005/01/08	0001h05m05s	14		0.0708	0.1187	0.1147	0.1179	0.0914	0.2551	77.1434
16:59:03 2005/01/08	0001h10m06s	15		0.0821	0.1235	0.1647	0.1091	0.0936	0.3109	77.2699
17:04:03 2005/01/08	0001h15m06s	16		0.0828	0.1348	0.2426	0.1161	0.1112	0.1697	77.1129
17:09:04 2005/01/08	0001h20m07s	17		0.0856	0.1386	0.1353	0.1229	0.1116	0.2940	76.9516
17:14:04 2005/01/08	0001h25m07s	18		0.0949	0.1494	0.2660	0.1327	0.1274	0.2194	77.1347
17:19:05 2005/01/08	0001h30m08s	19		0.0875	0.1637	0.0908	0.1346	0.1113	0.3714	77.3266
17:24:05 2005/01/08	0001h35m08s	20		0.0951	0.1656	0.2256	0.1323	0.1061	0.2923	77.0562
17:29:05 2005/01/08	0001h40m08s	21		0.0967	0.1774	0.1799	0.1341	0.1331	0.3725	77.0780
17:34:06 2005/01/08	0001h45m09s	22		0.0953	0.1855	0.3091	0.1455	0.1284	0.3860	77.3135
17:39:06 2005/01/08	0001h50m09s	23		0.1061	0.1929	0.2973	0.1478	0.1412	0.4038	77.3353
17:44:07 2005/01/08	0001h55m10s	24		0.1040	0.1958	0.3513	0.1489	0.1323	0.4048	77.0170
17:49:07 2005/01/08	0002h00m10s	25		0.1081	0.2120	0.3176	0.1535	0.1557	0.3637	77.0780
17:54:07 2005/01/08	0002h05m10s	26		0.1131	0.2144	0.3256	0.1641	0.1563	0.2580	77.3440
17:59:08 2005/01/08	0002h10m11s	27		0.1133	0.2169	0.3192	0.1725	0.1497	0.3550	77.2394
18:04:08 2005/01/08	0002h15m11s	28		0.1204	0.2349	0.2260	0.1785	0.1459	0.4907	76.9952
18:09:08 2005/01/08	0002h20m11s	29		0.1268	0.2371	0.2855	0.1649	0.1554	0.5920	77.1347
18:14:09 2005/01/08	0002h25m12s	30		0.1272	0.2417	0.4165	0.1701	0.1763	0.5220	77.3571
18:19:09 2005/01/08	0002h30m12s	31		0.1280	0.2542	0.2033	0.1838	0.1654	0.3971	77.1434
18:24:09 2005/01/08	0002h35m12s	32		0.1303	0.2631	0.3690	0.1829	0.1762	0.4843	77.0911
18:29:10 2005/01/08	0002h40m13s	33		0.1310	0.2634	0.2789	0.1885	0.1694	0.5239	77.2699
18:34:10 2005/01/08	0002h45m13s	34		0.1330	0.2751	0.3141	0.2005	0.1808	0.4767	77.3571
18:39:10 2005/01/08	0002h50m13s	35		0.1356	0.2817	0.3277	0.2082	0.1899	0.5853	77.1347
18:44:11 2005/01/08	0002h55m14s	36		0.1400	0.2899	0.4598	0.2010	0.1789	0.5523	77.0562
18:49:11 2005/01/08	0003h00m14s	37		0.1386	0.2953	0.3248	0.2135	0.1852	0.4656	77.3440

The Data View is split into four sections, so that the titles for the series do not disappear when the data is scrolled vertically, and the data point identifiers (Elapsed Time, Spectrum Number) do not disappear when the data is scrolled horizontally.

The top-right section contains header information that identifies and describes the series being displayed. There are a total of five lines which are the Series Title, the Macro Name, the Board Number, the Isotope/Window (or Parameter) Name and the Profile Name. Initially, only the first two are displayed, but this section can be scrolled vertically or re-sized to display the others. The bottom-left section contains the Date/Time, the Elapsed Time and the Spectrum Number for each data point. Initially, only the time portion of the Date/Time is displayed, but again, this section may be scrolled horizontally or re-sized to reveal the other parameters.

The bottom-right section shows the output data. It may be scrolled vertically to reveal earlier or later data, and of course, the left section scrolls vertically with it. Vertical scrolling may be achieved in two ways. At any time, the display can be scrolled with the scroll bar and mouse. Otherwise, if one clicks a line, the up and down arrows may be used to step through the data points, which scroll when the top or bottom of the screen is reached. One can also use the "Home" or "End" keys to step to the top or bottom of the data section, or the "Page Up" or "Page Down" keys to step through a page of output. This section may also be scrolled horizontally to reveal different series.

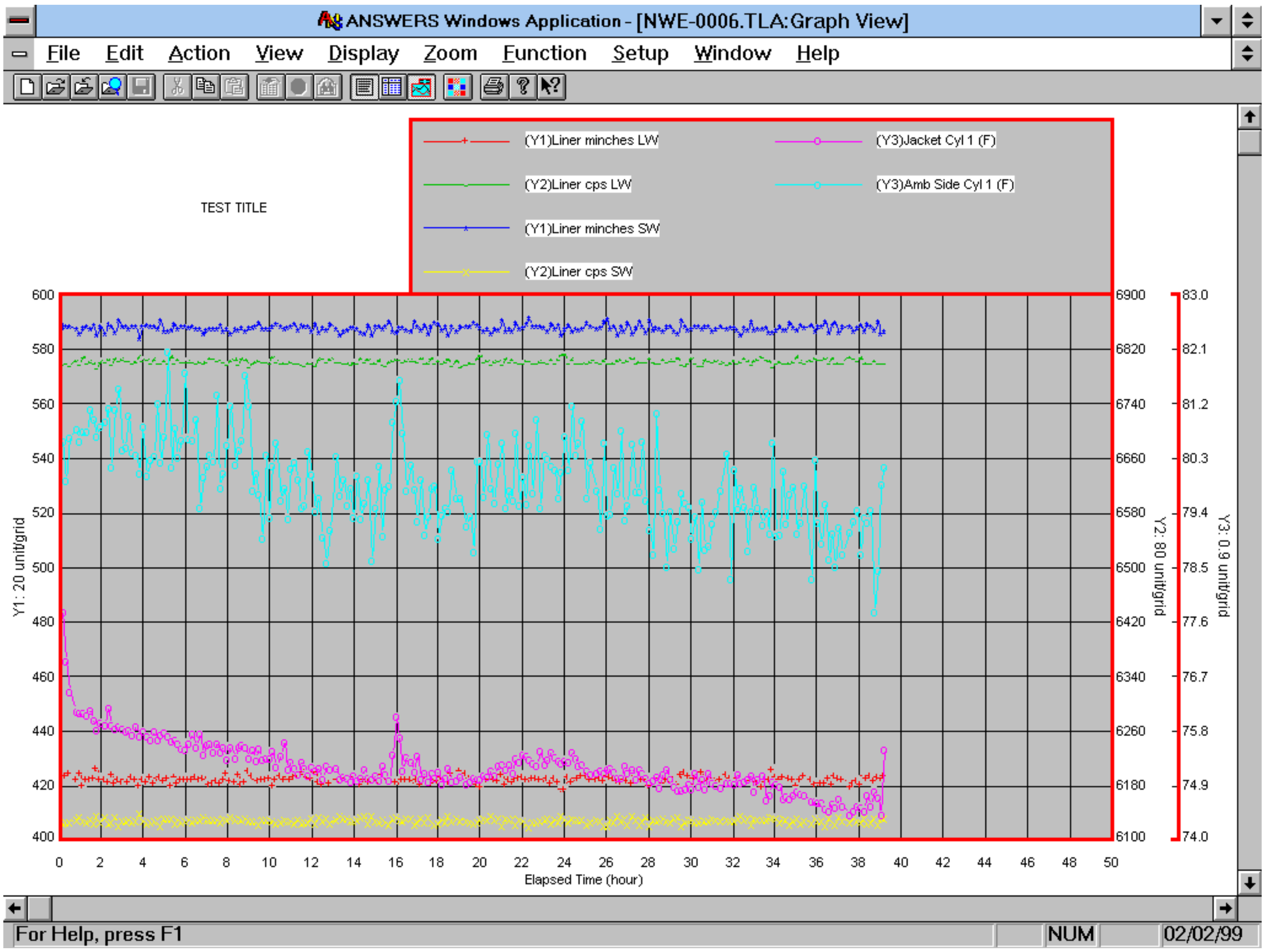
Figure 5 : Graph View (Single Series)



As one can see, the graph and fonts are always sized to fit within the window, and never chopped off. Three Y-axes are defined, and multiple series may be assigned to each one. When the Graph View is first invoked (as shown), the first series is assigned to Y1 and only that axis is displayed, using the default color and symbol. The Y-axis is sized so that the range of data is expanded to its maximum extent, **but there is a rounding algorithm that insures that the minimum and maximum values on the Y-axis are round, convenient numbers, that the number of units per grid is always one significant figure, and that there is no fraction of a grid.** Nonetheless, manual scaling or manual zooming may always be invoked by the user to yield whatever ranges and grid sizes are desired.

The Time Axis is similarly rounded, with the restriction that the full-scale is never less than 1 second, 0.5 minutes, or 0.01 hours. Further, as time progresses, the size of the resizing increments is increased so that when the time scale changes, the graph is compressed to not more than about 80% of its former size. This means that the user can get used to looking at the same time scale for a while. Figure 6 shows the Graph View for six series displayed on three Y-axes.

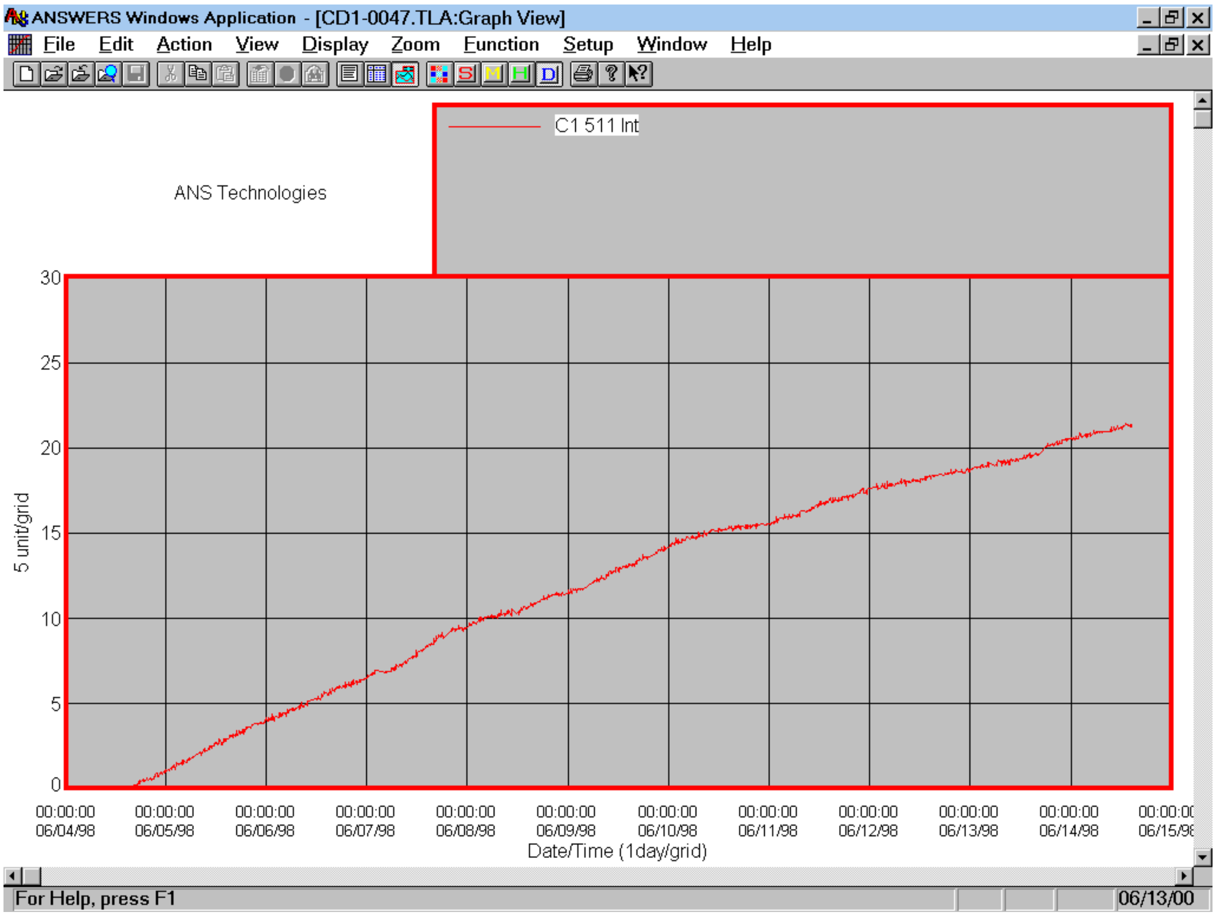
Figure 6 : Graph View (Multiple Series)



Whereas the left-hand axis determines the gridlines, the rounding procedure for the right-hand axes adjusts the minimum and maximum so that in addition to the constraints on the left-hand axis, the same number of gridlines are used. Up to eight series may be displayed at any one time.

As can be seen in Figure 4, the time axis is the Elapsed Time in hours. In fact, four different time units are available, namely seconds, minutes, hours and date/time. These units may be changed at any time, and the graph as well as all time references are updated. If the user selects seconds, minutes or hours, it is the Elapsed Time that is displayed. If, however, the user selects the date/time units, the time axis is the Date/Time, as shown in Figure 7.

Figure 7 : Graph View (Date/Time)



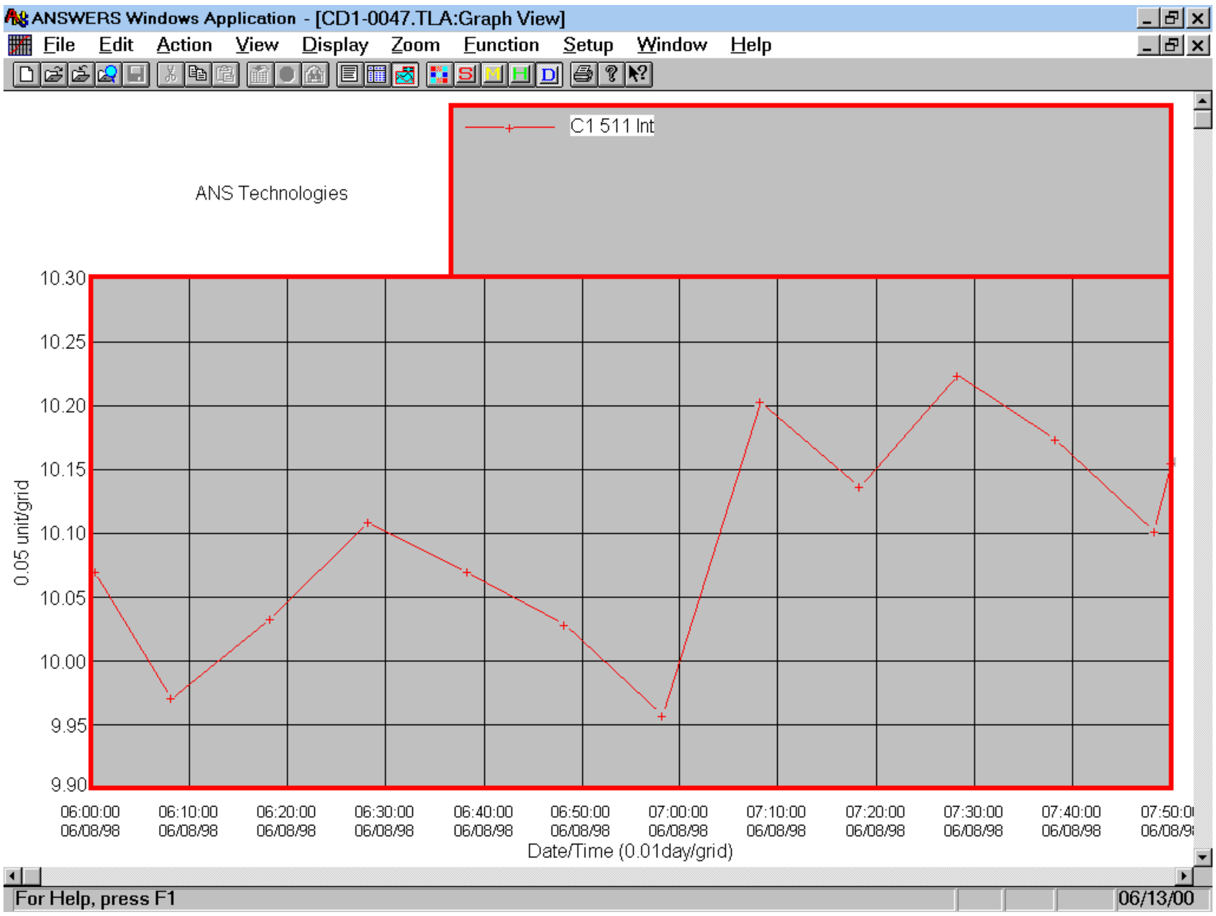
With a time axis rounded according to the Date/Time, the run will not typically start at the origin, since the start of a run is not usually at some rounded time of day. By rounding according to Date/Time, one can conveniently identify the date/time of a particular feature of the data, and relate it to other events in the experiment, as recorded by the date/time stamp of other computers. For this reason, it is a good idea to synchronize the date/time stamp of the Track-Wear PC with the other systems. Again, the user may use manual scaling or manual zooming to override the rounding procedure, and establish the minimum and maximum desired. The size of the rounding interval depends on the range of the data in time, as shown in Table 1.

Table 1 : Rounding

For time ranges less than:	The plot is rounded to the nearest:
1 minute	15 seconds
10 minutes	1 minute
20 minutes	2 minutes
2 hours	10 minutes
8 hours	1 hour
16 hours	2 hours
1 day	3 hours
3 days	6 hours
5 days	12 hours
ELSE	1 or more days

Further, the grid sizes are chosen automatically according to the ranges so that the sizes are convenient and the labels don't collide (unless one chooses a very large Windows font), as shown in Figure 8.

Figure 8 : Graph View (Expanded)



Zoom

ANSWERS is also equipped with a zoom feature which allows the user to zoom in on a particular region of the graph. The user has the option of a mouse-activated zoom, or one activated through a dialog box. In the first case, the user defines the region with the mouse, and may select one of three modes:

1. Select zoom on time axis but leave Y-axes alone
2. Select zoom on time axis and autoscale Y-axes to the zoom region
3. Select zoom on both axes by drawing a rectangle.

In addition, the rounding algorithm is invoked to make sure that the range is in round numbers. With the manual zoom, the user selects exactly what zoom region he wants on each axis independently, although all zooms must be within the displayed data.

Rate Calculation

Another feature of ANSWERS is the determination of a rate from any displayed series. The user selects the series, and defines the time range with the mouse. ANSWERS calculates the rate and standard deviation in the time units displayed. If the time units are then changed, the rate is updated.

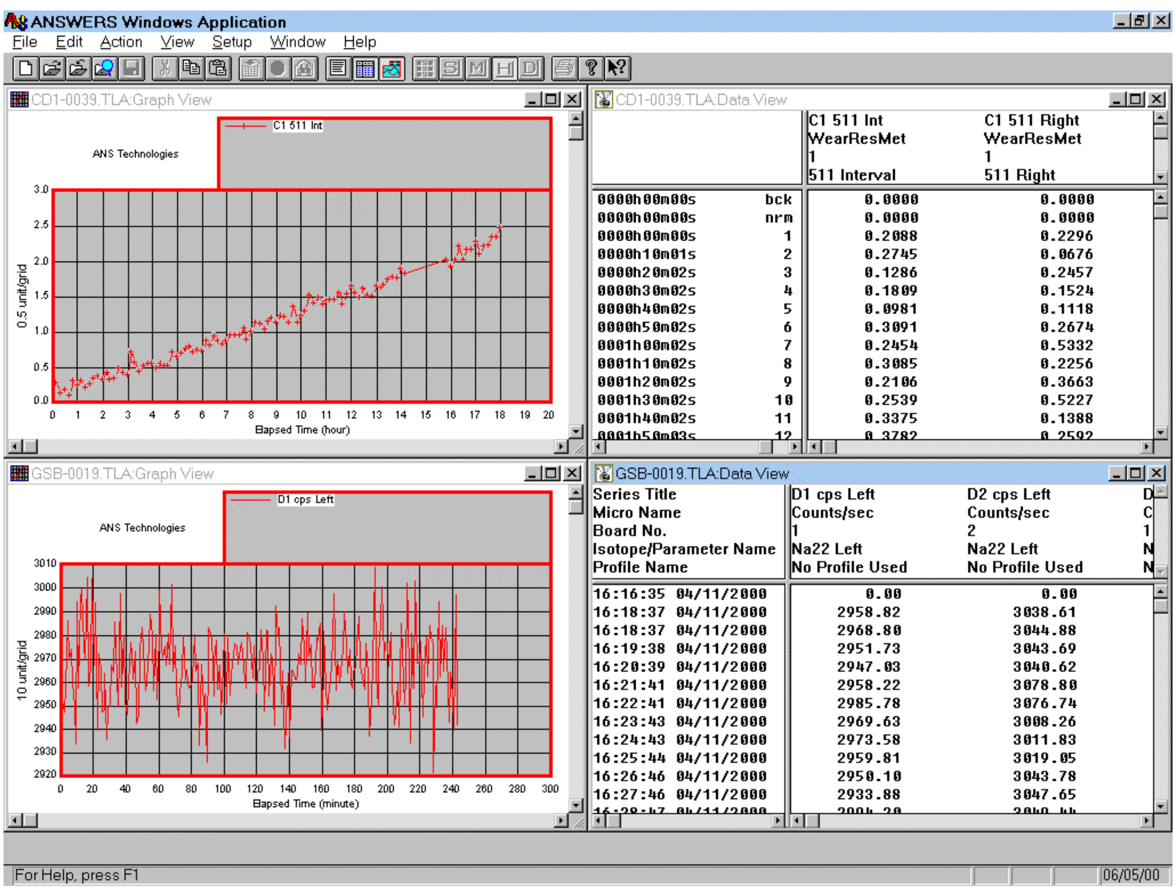
Series Combinations

ANSWERS allows the user to define a mathematical combination of series, such that corrected data may be displayed on-line. For example, one may correct wear data, point by point, with measurements of other parameters, such as temperature. One may also combine data from several windows to improve the precision of a meaured wear rate.

Other Features

ANSWERS is equipped with a number of other features. Graph colours and symbols may be modified, and the convention for the display of the date may be selected. Multiple windows from several data files may be displayed simultaneously, and tiled in normal Windows fashion (Figure 9). Further, the user may pre-define up to five layouts, which are customs sizing schemes for the three windows. A toolbar provides shortcuts to the most common functions. Many of the features available to Windows software are available with ANSWERS.

Figure 9 : Tiled Windows



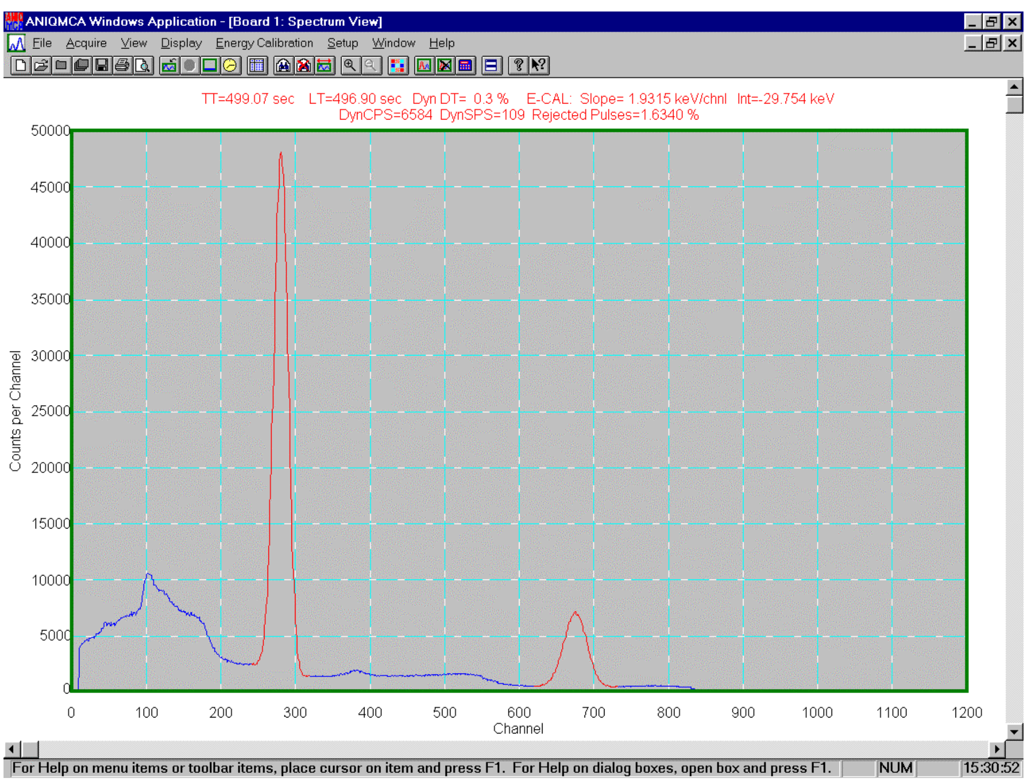
<u>**ANIQMCA Spectrum Acquisition and Analysis Software**</u>

General Operation
ANIQMCA is designed to acquire spectral data in single periods, and display the spectrum in graphical mode. It controls and downloads data from the ANIQSpec Spectroscopy Modules. ANIQMCA allows the user to open a number of documents, limited only by the memory of the PC. Each document is a histogram with an array size of either 1024, 2048 or 4096 channels. Each channel contains an integer from 0 to 2^{32}. ANIQMCA may be used to monitor data acquisition by ANSWERS.

On-Line and Off-Line Documents
When one creates an on-line document, a dialog box allows the association of the document with one of up to four ANIQSpec Spectroscopy Modules. When an on-line document is created, the associated board is immediately accessed, and the histogram data stored on the MCA board is copied to the document. Further, if ANIQMCA finds that this board is acquiring data, it begins its acquisition loop. Thus, if ANIQMCA has closed while one or more boards are acquiring, the boards continue to acquire (until any preset is reached). ANIQMCA may be restarted, and the data recovered. **Most importantly, the user may open as many on-line documents as there are MCA boards, and each one may have its live acquisition started and stopped independently.** The data may be saved on disk in an MCA file. An off-line document is created by reading an MCA file.

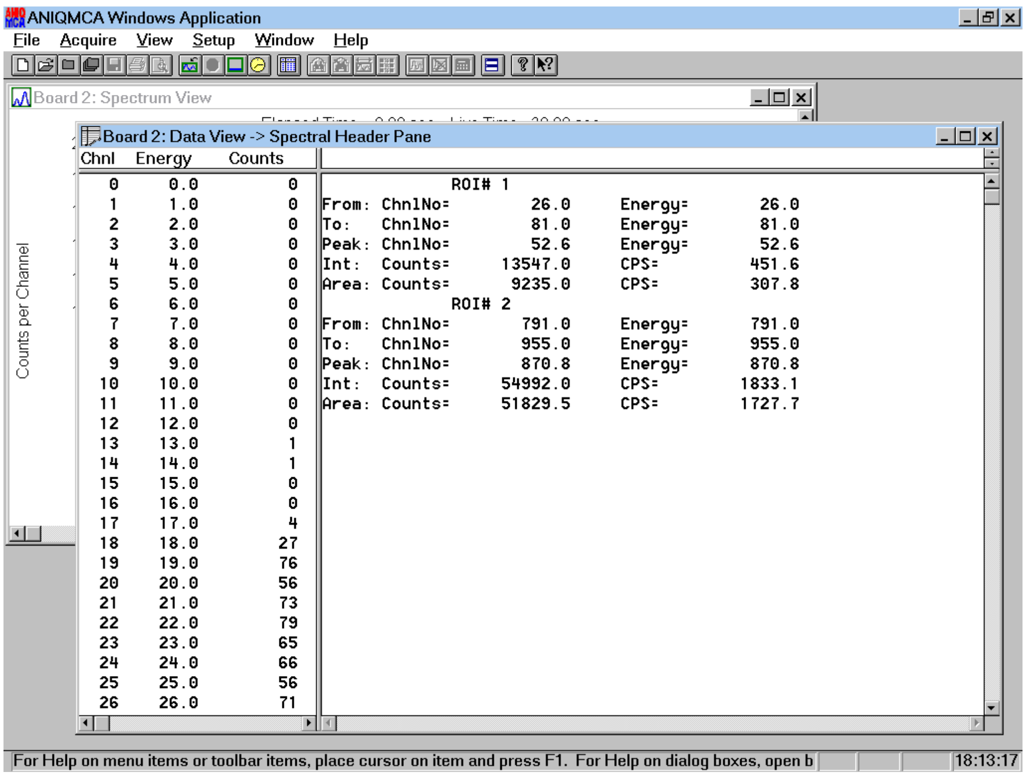
Spectrum View and Data View
The Spectrum View shows the spectrum graphically. There is a header that displays the True Time (TT), Live Time (LT) and percentage Dead Time (DT). If an energy calibration is in effect, the slope and intercept are also displayed. If an on-line document is displayed, the True Time and Live Time are read from the MCA board, while the calibration is read from the ANIQMCA.INI file.

Figure 10 : On-Line Spectrum View



If an off-line document is displayed, all the data is taken from the disk file's header, except the Dead Time which is calculated from the True and Live Times, and is thus an average. The number of counts is autoscaled, but this may also be modified with the PageUp, PageDown and Home keys. The range may also be manually or automatically scaled, and there is a Zoom feature to view close-ups temporarily. The user may set up to ten Regions-of-Interest (ROIs) on the spectrum. These ROIs are used both to calibrate the energy, and to perform analysis of a photopeak contained therein. If there is no energy calibration, the slope defaults to 1 keV/chan and the intercept defaults to 0 keV, thus making the Channel Number and Energy numerically equal. The Data View will display a table of the raw data, with columns for Channel Number, Energy and Counts. Also displayed, for each ROI, are data giving the range of the ROI in Channel Number and Energy, the centroid of the peak, the sum of the counts in the ROI, along with the counts per live second, and the area of the peak above the Compton background, in both Counts and CPS.

Figure 11 : On-Line Data View



Hardware Control

ANIQMCA is also used to define, save and transmit certain parameters and to the ANIQSpec2 Spectroscopy Module. The parameters are sent to the board's memory, and control how the input voltage pulses are analysed. If signals arriving at the amplifier have voltages exceeding the maximum (saturation), they are rejected and not processed by the ADC. However, the dynamic saturations per second and the percentage rejected may be displayed on the Spectrum View, and thus allow the user to determine if the input voltage is too high. If the rejected pulses are due to high-energy signals that are not of interest, it is not necessary to reduce the input gain. The rejection process does not hamper the acquisition of those pulses not being rejected.

Saving Documents

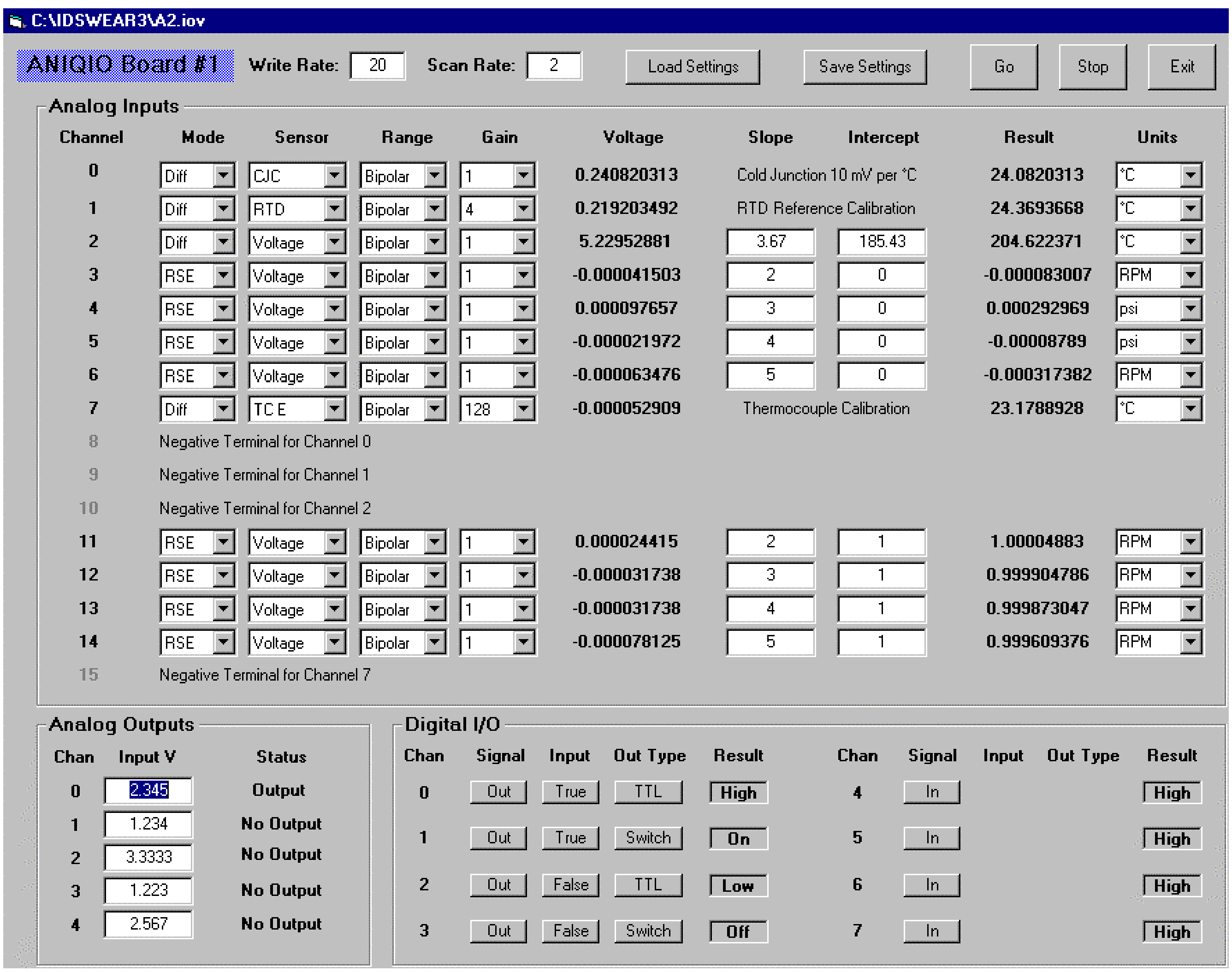
The contents of on-line documents may be saved in the MCA file format, to be viewed at a later date. This format also saves the energy calibration, the number of channels, the live and true acquisition times, as well as several other parameters. When a save is performed, the on-line document remains unchanged. Acquisition may continue, and the file saved again, potentially with the same name. The histograms of both on-line and off-line documents may be saved in ASCII format for viewing with other software. The contents of two off-line documents may be summed.

IOViewer Data Acquisition Software

General Operation

IOViewer is a general control, display and recording software for use with the ANIQIO board. Multiple instances of IOViewer may be called, one for each ANIQIO board present. A file with extension IOV is used to record the settings of the various I/O channels, as well as record the results of the periodic scan of the ANIQIO board attached. The "Scan Rate" determines the frequency the ANIQIO board is scanned and the display is updated. The "Write Rate" determines the frequency the data is appended to the IOV file.

Figure 12 : IOViewer Input and Display View



Analog Inputs

The analog inputs are processed according to a set of input parameters. The “Mode” determines whether the inputs are to be configured as Referenced Single-Ended (RSE) or Differential (Diff). In the RSE mode, any channel’s input voltage may be measured with respect to a common ground. In Diff mode, the input to Channels 0 to 7 may be measured with respect to Channels 8 to 15, respectively. The “Sensor” parameters determines which type of sensor is being used for that channel, be it a simple voltage signal, an RTD or one of five types of thermocouples. Channel 0 may be used for cold-junction compensation if thermocouples are used. The voltage read from the board is displayed, as is a result based on a calibration. For thermocouples and RTDs, the calibrations are internal to IOViewer, and the result is in terms of temperature. For simple voltage signals, the user may enter a linear calibration and give a name to the units.

Analog Outputs

The user may output a voltage via one of five AO channels. Within IOViewer, one merely enters the voltage in the box, and hit return. The appropriate voltage is output.

Digital I/O

For each of eight digital I/O channels, the user first selects the “Signal”, be it input or output. If output is selected, the user may select the “Out Type” for that channel, be it TTL or switch, and the desired results, either TRUE or FALSE. If “Out Type” is TTL, TRUE sends a 3.3 volt level, otherwise a zero volt level. If “Out Type” is Switch, TRUE turns on the switch, false turns it off. For both Output and Input, the result is shown at each scan.

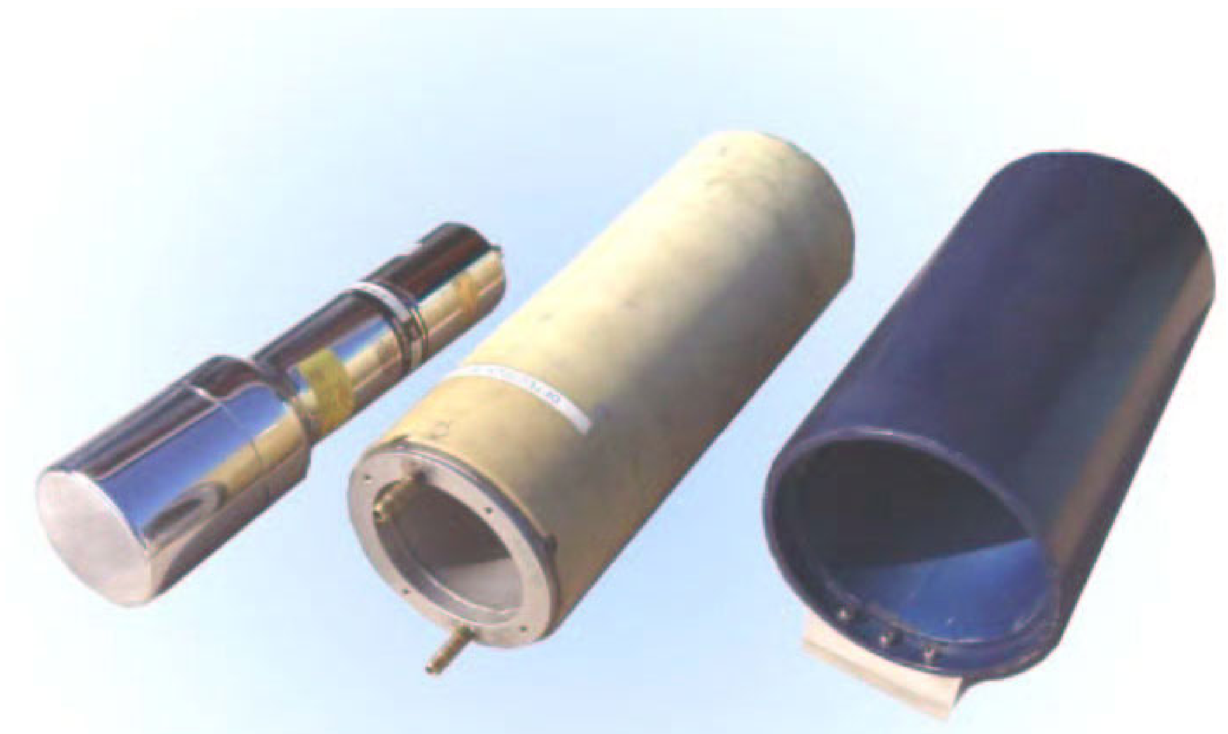
Support Equipment

Flow-Through Reservoirs: To use the Flow-Through Method, one measures the activity that accumulates in a reservoir in the lubricant circuit of the test apparatus and/or the filter. The reservoir and/or filter must be shielded (with lead) so that the greater activity on the component does not influence the measurement of the lesser activity in the oil. A number of reservoirs are available from ANS Technologies, depending on the nature of the rig, the accuracy required, and the quantity of oil. These reservoirs have incorporated cooling coils to stabilize the temperature of NaI the detector.

Figure 13: Flow-Through Reservoir for Heavy-Duty Deisel Engines

Water Jackets & Cooling System: If one intends to do Residual-mode measurements near hot engines (such as liner wear on a Diesel engine), a Water Jacket for each detector is necessary. ANS Technologies offers such units. A continuous flow of water at a constant temperature will keep the detector temperature reasonably constant. Any minor fluctuations in temperature will cause gain shifts, but these can be compensated with the software. However, it is strongly recommended that one purchase a thermostatic Cooling Control System. This system operates with a closed loop of coolant, and maintains the temperature of the detectors to within 0.2°C. Since the Water Jackets are connected in series, one cooling system can handle all the detectors one has.

Figure 14: Measuring Probe, Water Jacket and Lead Shield



Lead Shields & Support Stands: Sometimes one wishes to place 2 detectors opposite 2 components to measure, for example, the wear on 2 adjacent liners. In this case, each detector must be surrounded by a lead shield to prevent each from detecting the activity of the other's component. In general, such shields are good for eliminating background from natural radioactivity and cosmic rays, as well as Compton scattering from personnel moving in the immediate vicinity. The support stands for the detectors are tripods with heavy bases so that they support the weight of the detector and lead at a lever arm of 4 feet. Thus, the supports do not stand on vibrating surfaces, and avoid microphone pickup.

Table 2 : Track-Wear Features

PC	PentiumII / 32 MB RAM or better. At least 128 MB RAM recommended.
Detector Type	NaI, Ge or custom
Detector Size	3" x 3"
Optional Sizes	1" - 5"
Max. Number of Detectors	4
Spectrometer (MCA)	Each detector is connected to its own ANIQSpec2 Board. The boards are interfaced with the PC via the parallel port. Up to 4 boards may be installed, so that each detector operates independently.
Maximum Count Rate	Total Rate of 200,000 counts per second with less than 10% deadtime.
Operating Environment	Windows XP/2000/ME/98/95
SLA Software	ANSWERS V3.7 controls all MCA and I/O boards, collects data, analyses on-line, displays data and graphs.
Additional Software	The ANIQSpec system comes with ANIQMCA software, which controls up to 4 boards, displays the spectra, data and ROIs, and features a number of analysis tools.
Counting in Defined Energy Windows (ROI)	Independent windows (ROIs) defined by upper and lower energy, and related to MCA channels by an energy calibration. Counts from each ROI (with or without background subtraction) analyzed according to its own parameter set.
Max. Number of ROIs	10 (but may be increased easily)
Real-Time Analysis	Data extracted from spectrum (ROIs) & I/O card, and analyzed to produce wear or other physical measurements.
Depth Profiles	Yes
Data Storage	Spectra plus data file containing all extracted and analyzed data
Regeneration of data set from spectra	Entire data file may be regenerated from spectra. User may change ROIs and all analysis parameters.
Min Acquisition Interval	1 second
Customizing	For each customer.
NaI Detector Cooling	If the detectors are exposed to heat, they may be equipped with optional water jackets. If one wishes to precisely maintain the temperature to minimize gain shifts, a refrigerator/pump is available (±0.2 °C).
NaI Gain Stabilization	Software routine follows peak to correct for fluctuations in gain. If the detector is exposed to heat, it should be cooled. However, in many cases, it is not necessary to precisely maintain the detector temperature.
Residual Measurement Channels	All detectors may be run in residual mode without increase in dead time, as each has its own Flash ADC.
Flow-Through Measurement Channels	All detectors available.
Additional I/O System	The ANIQIO board allows user to include measurements of test bench parameters (such as temperature) to be recorded, analyzed and displayed.
Customer Service	ANS warrants Track-Wear hardware and software for one year, including upgrades. Extended warranty plan available. The detectors are warranted by their manufacturer.

Table 3 : ANIQSpec2 Specifications

Amp/ADC/MCA Board	VME 3U Slot; Lemo input to Amp/ADC/MCA, DB25 bypass input directly to MCA; jumper ID select; 300 mA power consumption
Amp	Input Gain controlled by trimpot; Fine Gain and Shaping controlled by software; stability 200ppm/°C
ADC	Flash ADC; 300 ns Process Time; 0.03% integral stability; 1% differential stability; stability 100ppm/°C. ADC Gain controlled by software.
Interface Board	VME 3U Slot, Interface to EPP 1.9 Parallel Port
Processor	ALTERA EPF10K30 RC208-4 programmed with ANIQ firmware
Memory	1 chip 128K x 32-bit
Access Time	15 ns
Backplane	VME-A24D16 3U
Power Supply	Output +5V, 5A max ; +12V, 2A max; -12V, 0.2A max
Chassis	6.5" W x 8" D x 5.5" H
ANIQHV Board	1 kV, 1 mA; 0.001% regulation; stability 25ppm/°C; voltage display; control pot or remote control; power 12VDC, 1A

Table 4 : ANIQIO Specifications

IO Board	VME 3U Slot, Interface to connector block with 50-pin cable.
Processor	ALTERA EP1K30 TC144-3 programmed with ANIQ firmware
Analog Inputs	16 single-ended analog inputs (pairs may be configured in differential mode). Inputs may be up to 40 volts unipolar or 20 volts bipolar. Voltage precision less than 0.1 mV (for thermocouples). On-board cold junction compensation. Four-wire PT100 RTDs may be directly connected and are calibrated for any length of wire.
Analog Outputs	5 analog outputs of 0-4.096 volts in increments of 1 mV (12-bit).
Digital I/O	8 DIO channels. Outputs may be either TTL voltages or switch mode.

Table 5 : ANIQ MCA14 Specifications

Amp/ADC/MCA Board	VME 3U Slot; SMA input to Amp/ADC/MCA; jumper ID select; 300 mA power consumption
Amp	Gain and Shaping controlled by software; stability 200ppm/°C
ADC	Flash ADC; 300 ns Process Time; 0.03% integral stability; 1% differential stability; stability 100ppm/°C. ADC Gain controlled by software.
Interface Board	VME 3U Slot, Interface to EPP 1.9 Parallel Port
Processor	Altera Cyclone 12 programmed with ANIQ firmware
Memory	On processor, 128K x 32-bit
Access Time	15 ns
Backplane	VME-A24D16 3U
Power Supply	Output +5V, 5A max ; +12V, 2A max; -12V, 0.2A max
Chassis	6.5" W x 8" D x 5.5" H
ANIQHV Board	1 kV, 1 mA; 0.001% regulation; stability 25ppm/°C; voltage display; control pot or remote control; power 12VDC, 1A