12 Garden Street • Danvers • Massachusetts 01923 • 508/774-1880
FAX 508/774-5202
TELEX 951464

030-31414

M/K SYSTEMS INC.

April 17, 1990

NUCLEAR REGULATORY COMMISSION
475 Allendale Road
King of Prussia, Pennsylvania 19406

Attention: Chris Eckert

Dear Mr. Eckert:

We wish to withdraw our application (Main Control No. 111643) for a license to use a 3 mCi Promethium 147 source from Amersham in conjunction with the Ambertec Formation Tester.

Yours truly,

M/K SYSTEMS, INC.

Otto J. Kallmes

OJK/a
c: John D. Kinneman, NRC
Antero Komppa, Ambertec Oy

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U.S. NUCLEAR REGULATORY COMMISSION

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3:30 PM 4-16-90

Mr Kallmes, M/K Systems 030-31414

New license request, program code 3122.

Mr. Kallmes called and stated that after reviewing the deficiency letter he has decided not to obtain a license for the gas chromatograph. He will continue to distribute by not taking possession of the actual source.
Mr. Kallmes was asked to forward a letter requesting the action be voided. Will comply.

C Eckert. No action required at this time.

CJ[illegible] 4-16-90

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AMBERTEC Oy (Ltd)
P.O.Box 69
02271 ESPOO, Finland
Phone : +358-0-822 802
Fax : +358-0-822 803

MS-16
L-2

Date April 06, 1990

U.S. Nuclear Regulatory Commission
Region I
Attn : John D. Kinneman
Chief, Nuclear Materials Safety
475 Allendale Road
King of Prussia
Pennsylvania 19405
U.S.A.

RE: AMBERTEC Beta Formation Tester

Dear Sir,

I just got a copy of your letter to M/K Systems Inc. (dated Mar.05,1990, Docket No. 030-31314, Control No. 111643). I would like to comment on some of the topics in the order mentioned in your letter.

1) The sealed Promethium sources in question are made by Amersham International, U.K. and imported to U.S.A. by Amersham Corporation (Illinois, contact person: Mr. Hugh Evans). The activity of the source is 3 mCi and the active material is encapsulated in a type PHC.32 capsule. According to the manufacturer the source is a mixture of promethium oxide and silver that is sandwiched between thin palladium and silver layers. Amersham International supplies the sources under type code PHCK 3556.

2) The gauge is used for measurement of formation of paper (i.e. the basis weight distribution of paper in a very small scale). The source is an integral part of the tester and is located inside the tester in such a way that the user may not have access to the source without special tools (e.g. an Allen key screwdriver of suitable size).

3) M/K Systems Inc. is a distributor of the tester in the U.S.A. The tester will be sold mainly to papermills and it will be used by personnell (technicians) that are authorized by NRC to use radioactive sources. Thus the customer's personnell already do possess the basic knowledge in radiation safety.

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The beta radiation source in the tester will be replaced every third year. The mill personnell in charge of radioactive material will carry out the

work according to instructions given in the manual of the tester (see a copy enclosed). M/K Systems Inc. could also safely install the source into the tester according to these instructions.

All servicing of the tester will be carried out by AMBERTEC Ltd specialists, in Finland.

M/K Systems Inc. will provide operator training, too. However, please, note that the customer's operators in question already do possess the knowledge in radiation safety.

4) I have personally trained Dr. Kallmes to use the tester as well as to install and to handle the promethium-147 source. The training was carried out twice (in June 1989 in Finland, for 2 days and in October 1989 in Switzerland, for a half day).

AMBERTEC Ltd is authorized to possess and to use the above sources by the Finnish governmental office for radiation safety (STUK, Säteilyturvakeskus, license nr. 4136/L1/89).

In the training we have covered all the topics necessary.
- The principles of radiation protection and good safety practices (see the copy of the manual, as well).
- Biological effects of radiation (with the Pm-147 source in question the radiation will easily be stopped by clothing or the outest layer of skin: the radiation will not penetrate through a material layer of 350 g/m2).
- Handling of the Pm-147 source
- Procedures for performing the services requested and
- Actual practices in performing the services

We have only very slightly covered the radioactivity measurements and use of detection instruments or monitoring techniques: **as the source is a sealed one and a very tiny one <u>the Finnish (STUK) and the Swedish (SSI) governemental offices do not require a monitor or a dosimeter at all</u>**.

5) I suppose that the Item 8. in the M/K application states the <u>number of customers</u> for which the training is given. I repeat the point (Item 3, above) that the users have qualification in radiation safety already and the M/K systems only provides the necessary special skills for the use of the tester.

Basically the M/K representative will teach the information given in the operation manual (copy enclosed).

6) No commens.

7) Basically, the purchaser will be in charge of the sources (purchasing, installation, returning the depleted sources etc.). As already mentioned in our Item 3 above, the people in charge of the use of the tester do have qualification in radiation safety. Hence, the ordering, receipt, installation,

safe handling and return procedures are familiar to them already. I am sure you do know that the mills do use much stronger sources in the paper machine on-line basis weight gauges (usually containing krypton, strontium or thallium isotopes).

The sources are ordered from Amersham Corporation according to the type code above (PHCK 3556, 3 mCi Pm-147 in PHC.32 type capsule X110). Mr. Hugh Evans at Amersham will be in charge of the deliveries (we have already bought the PHC.32 sources from Amersham International for about 25 years).

The source will be delivered in a tin can, containing a lead can, according to the safety precautions. The purchaser is advised to store the can as well as the documents enclosed with the source. The old decayed source will then be returned to Amersham Corporation in the original package.

8) The leak testing will be carried out by the supplier of the source, Amersham Corporation.

The manufacturer, Amersham International carries out both a wipe test and an immersion test for each of the sources.

According to NRC NR-129-D-101-S (page 4) the source shall be leak tested at intervals of max. 6 months. The license does not give any statement on the type of the leak test but mentiones that the detection of the presence of 0,005 microcuries of the radionuclide must be possible.

9) The leak test will be carried out by Amersham Corporation. The possible decontamination procedures as well as the handling of the possible leaking source is done by Amersham Corporation, not by M/K systems.

The source is in a solid form, sandwiched between solid silver and palladium foils. The source itself is fixed into a cavity at the end of a stainless steel rod (the PHC.32 capsule). The source is placed inside of a solid brass source holder with a collimator hole of 1 mm in diameter. Above the source holder is a solid brass sheet pressing cup and the aluminium tube containing the scintillation detector. Thus it is practically impossible to reach the source during a normal operation and there has been no case of a leaking or a damaged source during the 25 years we have been using these sources.

The AMBERTEC Beta Formation Tester, containing a **five millicurie Pm-147 source** was examined: During the use of the tester no external radiation above the background could be found on the accessible surfaces of the tester. Scatted radiation (1.7 millirem per hour) was measured for an empty meassuring gap at 10 cm distance. Contact dose rate at the collimator opening (with the collimator removed from the tester) was 60 millirem per second and the contact dose rate for the 5 mCi source was 12.5 rem per second.

10) As the radiation of the Pm-147 source is very soft beta, only some special testers will be able to detect the radiation. AMBERTEC uses a BERTHOLD LB 1200 -tester with a special window for the soft beta.

In the Scandinavian countries no radiation testers will be required. The NRC license NR-129-D-101-S neither does specify any tester necessary.

11) Please, note, that the source is of Promethium-147 and the activity is 3 mCi only. As mentioned in Item 9, above, during the use of the tester no external radiation above the background can be found on the accessible surfaces of the tester. Therefore no personnell radiation dosimeters will be necessary.

The source will be removed for leak testing twice a year and the removal/installation will take about 30 seconds at the most. The removal and installation of the source will be performed by mill personnell in charge of the radiation safety, authorized by NRC or Agreement States.

12) As mentioned above in Item 3 all necessary servicing of the tester will be carried out by the manufacturer, AMBERTEC Oy (Ltd.) in Finland.

M/K Systems Inc. will use and train the operators to use the tester in accordance with the manufacturer's specifications and instructions.

13) As mentioned above, in Item 5, M/K Systems Inc. will provide the operator training necessary for the customer. The topics include the radiation safety, handling of the source, installation and removal of the source, the use and the calibration of the tester according to the operation manual (copy enclosed).

I enclose a copy of the original documents sent to NRC for the registration of the tester that will provide you more information about the tester in question.

You do state in your letter that you would close the procedure in case of no reply within 30 calendar days. As I received the copy a couple of days ago, I wish that you would, however, still consider the case if M/K Systems Inc. would still like to proceed.

Should you have any comments or questions about the tester or about our qualification, please do contact us either via telephone or telefax - the mail takes up to a couple of weeks to reach us.

Sincerely
AMBERTEC Oy (Ltd)

Antero Komppa
M.Sc.(Eng.), Chairman

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cc. Dr. Otto Kallmes, M/K Systems Inc.

APR 09 1990

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AMBERTEC

AMBERTEC Oy (Ltd)
P.O.Box 58
02271 ESPOO, Finland
Phone : +358-0-882 902
Fax : +350-0-882 963

Date April 06, 1990

M5-16
L2

U.S. Nuclear Regulatory Commission
Region I
Attn : John D. Kinneman
Chief, Nuclear Materials Safety
475 Allendale Road
King of Prussia
Pennsylvania 19405
U.S.A.

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- Handling of the Pm-147 source
- Procedures for performing the services requested and
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Should you have any comments or questions about the tester or about our qualification, please do contact us either via telephone or telefax - the mail takes up to a couple of weeks to reach us.

Sincerely
AMBERTEC Oy (Ltd)

Antero Komppa
M.Sc.(Eng.), Chairman

cc. Dr. Otto Kallmes, M/K Systems Inc.

AMBERTEC

APPLICATION FOR RADIATION SAFETY EVALUATION AND REGISTRATION

1. SUMMARY DATA

Date : June 16th, 1989

Applicant : AMBERTEC Ltd., P.O.Box 58, 02271 Espoo, Finland
(Manufacturer)

Contact: Mr. Antero Komppa, M.Sc.(Eng.), Chairman
Phone: +358-0-882 902
Telefax: +358-0-882 963

Device type : Formation tester (off-line basis weight gauge for laboratory use)

Model : Type SFT-1, all testers are numbered according to :
mmyynnn, (e.g. 0589009)
where mm=month, yy=year, nnn=serial number

Other companies involved :
M/K Systems Inc., 12 Garden Street, Danvers,
Massachusetts 01923
(Distributor)

Contact: Dr. Otto Kallmes
Phone: 508/774-1880
Telefax: 5087774-5202
Telex: 951464

Radioactive source model:
Amersham PHC.32, Pm-147, capsule type X110
Distributor : Amersham Corporation, U.S.A.

Radionuclides and maximum activity :
Promethium-147, activity 5 mCi ± 20%

Leak test frequency :
The sealed sources will be leak tested by the manufacturer (Amersham International, U.K.)
See Appendix A.

Principal use codes : E : Beta gauges

The device is proposed for use under a general license.

The device is not a custom one.

AMBERTEC Oy
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SF-02271 ESPOO
Finland

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KOP 111210-133562
SYP 229036-8285
PSP 50949-1

Ly
0657045-0

2. SUMMARY DESCRIPTION

The AMBERTEC Beta Formation Tester is a basis weight gauge aimed for off line use at paper mill quality control laboratories. The tester is used to measure the basis weight variation of paper in a small scale and thus a very small measuring aperture (1 mm in diameter) is used. See the brochure (Appendix B).

The tester is used at fixed locations typically in paper mill laboratories by trained personnell only.

Design of the tester

The detector assembly consists of a scintillation counter tube detector and of a collimator and source holder. The collimator and the source holder are mounted onto the lower beam of a rigid aluminium frame and the detector with a sheet pressing cup is mounted onto the upper beam of the frame. The fastening of the detector prevents accidental or unauthorized removal of the source. See the drawing in Appendix C.

During the measurement the detector assembly is scanned over the paper specimen sideways and the specimen is advanced a step after each scan. All motions are performed using stepper motors.

The tester has been designed in such a way that a number of samples - sufficient for 8...30 hour measuring time - may be simultaneously loaded into the tester. The measurement is carried out automatically without the need of an operator to stand by. Even when measuring single sheets the operator would load the tester with samples every 10...20 minutes only, depending on the measuring parameters used. An operator with proper skill loads the tester with samples in less than 30 seconds.

The beta source

The beta radiation source Amersham PHC.32 is a sealed one, in an Amersham X-110 type capsule (a stainless steel rod, length 10 mm, 2 mm in diameter; the active foil disc, 1.3 mm in diameter is fastened into a cavity at the end of the rod). The source holder is machined for the X110 capsule only - no other size capsules (sources) may be used.

Please note that all sources in question are imported to the U.S.A. by Amersham Corporation. AMBERTEC sells and delivers the testers unloaded only. The purchaser separately buys the source and installs it to the tester.

Source holder and collimator

The beta source is placed inside the holder piece (see the drawings in appendices C and D). The holder is screwed inside the collimator and is secured to it's place using a locknut. The holder, collimator and locknut are made of solid brass. Thus the source is surrounded with solid brass (at least 2.5 mm in thickness) all over except the

collimator hole (1 mm in diameter and 2.5 mm in length). The source will be retained in it's place even in the case of fire up to the melting point of the brass collimator piece.

The source/collimator assembly is placed into a hole at the lower beam of the detector frame. The collimator hole points upwards (to the detector).

Collimator/detector assembly

On top of the collimator there is a solid brass sheet pressing cup, 59 mm in diameter, that slides up and down along the detector tube collar (made of anodised aluminium). There is a drilled hole in the cup, 3 mm in diameter pointing towards the collimator tube. The sheet pressing cup has two functions :
- firstly it acts like a shutter closing the measuring gap and
- secondly it presses the sheet against the collimator thus preventing any measuring errors due to sheet fluttering in the gap.

The detector is fixed into a collar that - in turn - is secured onto the upper beam of the detector frame using Allen key screws. Thus the beta source may not be accidentally removed from the device.

Measuring gap

The measuring gap is adjusted to a height of 2 mm with the sheet pressing cup at the topmost position (normally the gravitation forces the cup down to the collimator). The no parts of the human body may have access to the actual measuring gap.

External radiation levels

The tester has been tested by the Finnish and Swedish governmental offices for radiation safety. Under normal use no external radiation was observed even when using 8 mCi sources that were available at that time. At the moment the highest activity available through Amersham is 3 mCi in this kind of a source.

According to measurements carried out by the Swedish governmental office for radiation safety (SSI) following levels of radiation were observed as the tester was <u>loaded with a 5 mCi Pm-147 source :</u>

<u>Assembled device, measured as close to the beta source as possible:</u>

- <u>less than 2 µSv/h</u> with paper in the measuring gap, i.e. with closed gap,

- 17 µSv/h with totally open (2 mm), empty gap

<u>Assembled device, measured at the gap level, at a distance of 10 cm from the source:</u>

- less than 2 µSv/h with totally open (2 mm), empty gap

µSv/h = microsievert per hour
µSv/s = microsievert per second
1 µSv/h equals to 0.1 mrem/h (mR/h)

The measurements were carried out by SSI, Sweden, using a Philips ZP 1430 GM tube with brass lens (made by SSI) and a Bicron type Labtech scaler ratemeter.

Experience with the testers

At the moment there are 16 devices with similar source and detector arrangement in use at paper mills and research laboratories both in Finland and in Sweden (see Appendix B for the List of References).

3. DETAILS OF CONSTRUCTION AND USE

3.1 Conditions of Use

The tester itself does not set any special requirements for the operating conditions. However, as paper is very hygroscopic all measurements of paper usually are carried out under a controlled climate. Thus the temperature usually is about 25 centigrades and the humidity about 50 per cent. The climate is standardized all over the paper industry. Therefore all Beta Formation Testers may be considered to be operated approximately under the above conditions.

Due to the above the tester is installed in a fixed position - usually in an air conditioned laboratory. The tester is used by trained personnell with adequate skill; in most mills other persons have restricted admittance only to the laboratory facilities.

The measurement of a specimen will be done in about 10 minutes. The loading of a sample into the tester takes less than 30 seconds by a properly trained operator. Normally the tester is used to automatically measure multiple sheets (up to 100 sheets at a time possible) or cross directional strips of the paper web. Thus the operator usually loads the tester once a day (or once per 8 hour shift) only.

The approximate expected useful life of the tester is 15 years.

The source, the detector and the scaler are commercially available products and thus may be found in other products but very likely no parts of the AMBERTEC Beta Formation Tester would be removed for possible other uses.

3.2 Details of Construction

See drawings in Appendices C and D.

The source holder and collimator are made of solid brass. The holder will be screwed inside the collimator and secured to it's place by a brass locknut. The source holder/collimator assembly seats in a hole on the lower beam of the rigid detector frame made of solid anodised aluminium.

The source will be inserted inside the holder into a hole, 2.1 mm in diameter and 10 mm long. Only the Amersham X110 size capsule will fit in. To enable easy and safe removal of the source a small hole, 1 mm in diameter, has been drilled to the lower end of the source holder through which the source may be pressed out using a needle.

The diameter of the collimator flange is 35 mm and the upper end of the flange is curved for easy insertion of the paper specimen into the measuring gap. In the middle of the flange there is a precisely machined collimator hole, 1 mm in diameter and 2.5 mm in length. As there is no foil on top of the hole some paper dust may enter the hole during a

longer period of time. For the dust removal there is a hole drilled at the side of the collimator flange and a groove is machined to the upper end of the source holder.

The dust is removed from time to time as follows (the procedure has been given in Appendix G, section 7): a piece of board is inserted to the measuring gap and the sheet pressing cup is lifted up using the board. The nozzle of the air bellows (pumpette) supplied with the tester is placed into the hole aside of the collimator flange and a couple of squeezes of air is pressed into the collimator. Due to the metal sealing of the source no contamination of the dust has been observed throughout the years of the testers in use.

The NE 810 DM1-1 (NE Technology Ltd, U.K.) detector is fixed into a collar made of anodised aluminium and this, in turn, is fixed to the upper beam of the detector frame using two Allen key screws. Thus a tool (suitable size Allen key only) is required to obtain access to the source holder.

The sheet pressing cup (59 mm in diameter, of solid brass) is precisely machined for easy sliding on the collar of the detector tube. The hole for the beta radiation beam in the middle of the cup is 3 mm in diameter. The brass cup acts as a shutter that automatically closes the gap (by gravitation) whenever there is no sample in the gap. As the cup also presses the sample against the collimator to prevent the sample sheet fluttering in the gap, the gap is virtually closed even during the measurement.

The measuring gap height is adjusted to 2 mm. Due to the dimensions of the pressing cup, the collimator and the measuring gap no parts of a human body may have access to the beam of radiation.

The detector frame is scanned over the sample sheet driven by small stepper motors.

All of the above parts are precision made by automatic machining units to ensure best possible precision of the measurement.

3.3 Labeling

The yellow/magenta label (see Appendix E) is fixed on the left side cover of the scanner unit. The label is made of LEXAN plastics and is cemented onto the plastic cover. A label, engraved in aluminium (see Appendix E) is attached to the lower end of the source holder.

3.4 Testing of Prototypes

The tester has been used in various forms of prototypes (but with the same measuring geometry and safety arrangements) since 1975.

In May 1989 there were 9 sets of the AMBERTEC Beta Formation

Tester in use in Scandinavia (Finland and Swede.., See Appendix B for a list of references). These testers have been tested and accepted by the local governmental offices for radiation safety.

The tests carried out comprised the measurement of external radiation of the assembled device as well as the one with disassembled collimator/source holder (see 3.6 Radiation profiles).

As mentioned above in 3.2 the height of the measuring gap is 2 mm. The beam, collimated to 1 mm in diameter is in the middle of the brass sheet pressing cup, 59 mm in diameter. Due to these dimensions the user does not have access to the beam.

The cup both acts as a shutter (by gravitation) and reduces measuring errors by keeping the sample paper sheet well pressed against the collimator. As this simultaneously virtually closes the gap even during the measurement no radiation will escape outside the measuring gap.

E.g. in Sweden it is required that the source would not get lost even in the case of fire. The all brass construction of the collimator/source holder piece has been considered to be sufficient to fulfill this requirement.

3.5 Quality Control

All the mechanical parts of the tester (i.e. the specimen scanner unit with the source/detector assembly) are manufactured in series of 50 each in numerically controlled automatic machining units. The machining programs are stored and used for successive series. Thus all of the testers are mechanically identical as precisely as possible.

All testers are assembled by AMBERTEC. Each tester is tested (run) for two weeks, loaded with a 3 mCi Pm-147 source, before the shipment. Ahead of the shipment each tester is still inspected and calibrated by the Helsinki University of Technology, Helsinki, Finland (Appendix F).

The testers are used to measure formation of paper at paper mills and laboratories. The formation results usually are compared between mills and therefore it is essential that the testers precisely operate in an equal way to give reliably comparable results. This is why the mechanics especially the source/detector assembly affecting the measuring geometry is machined within strictest tolerances.

3.6 Radiation Profiles

The tester has been tested by the Finnish and Swedish governmental offices for radiation safety. Under normal use no external radiation was observed even when using 8 mCi sources that were available at that time. At the moment the highest activity available through Amersham is 3 mCi in this kind of a point source.

According to measurements carried out by the Swedish governmental office for radiation safety (SSI) following levels of radiation were observed. Please note that in the test the tester was loaded with a 5 mCi Pm-147 source as the sources obtainable today are of 3 mCi only :

Assembled device, measured as close to the beta source as possible, at the sheet pressing cup, at the height of the measuring gap:

- less than 2 µSv/h with paper in the measuring gap, i.e. with closed gap,

- 17 µSv/h with totally open (2 mm), empty gap

Assembled device, measured at the gap height, at a distance of 10 cm from the source:

- less than 2 µSv/h with totally open (2 mm), empty gap

As the collimator (loaded with the source) is removed from the detector frame a rate of 600 µSv/s was observed at the collimator tube opening.

The source, removed from the collimator gave a rate of 125 mSv/s.

µSv/h = microsievert per hour
µSv/s = microsievert per second
1 µSv/h equals to 0.1 mrem/h (mR/h)

The measurements were carried out by SSI, Sweden, (the Swedish governmental office for radiation safety) using a Philips ZP 1430 GM tube with brass lens (made by SSI) and a Bicron type Labtech scaler ratemeter.

3.7 Installation

The tester, consisting of the specimen scanner unit, the control electronics unit, the PC-type computer and the matrix printer is usually installed and used in an air-conditioned laboratory room, assembled on a table.

The installation is very straightforward and easy and is usually carried out by the purchaser (assistance may be obtained from the distributor if necessary).

The user will also load the tester with the beta source. Again, the procedure is very straightforward and easy.

All necessary instructions for the above installation are clearly stated in the operating manual of the device. (See Appendix G, sections 3, 7 and 8.)

3.8 Radiological Safety Instructions

The necessary radiological instructions and cautions are given in the operation and maintenance supplied with the tester. See Appendix G, Sections 1, 7 and 8 for documentation included in the manual.

3.9 Documentation Accompanying the Device

The supplier of the source, Amersham Corporation, will supply the necessary documentation accompanying the source (this includes the Radioactive source test report and the Packing note, see Appendix A).

AMBERTEC will deliver the Beta Formation Tester only, without the beta source.

A comprehensive operation and maintenance manual is supplied along with the tester with necessary instructions for the routine use and for radiological safety.
See Appendix G,
sections 4, 5 and 6 (principle of operation, routine measurement and calibration of the tester) and
sections 1, 7 and 8 (radiological safety and handling of the source) and.

3.10 Servicing

Along with the delivery of each device a half a day operator training course is given, dealing with the routine use and maintenance of the tester as well as the necessary radiological safety precautions for the use of the tester and for the handling of the source.

The tester will be delivered assembled but not loaded with the source.

Installation, relocation and routine maintenance of the tester is done by the purchaser.

The purchaser (assisted by M/K Systems Inc. if necessary) installs and replaces the source. The procedure is clearly stated in the operating manual of the tester.

Possible repair is done by AMBERTEC or by the local representative M/K Systems Inc.

Each tester is calibrated before the delivery. Routine calibration is frequently done by the purchaser (the necessary calibration procedure is a part of the tester computer program).

Leak testing of the source is done by Amersham International, U.K. A test report follows each source delivered (see Appendix A). As the source is metal sealed no further leak testing has been found necessary.

Due to the construction of the tester and to the type of the

source no routine radiation survey is considered to be necessary.

3.11 Leak Testing

Amersham International tests each of the sealed sources before the delivery (see Appendix A). The useful life time of the source is about 3 years. Further testing has not been considered necessary according to our experience about these sources since about 20 years.

The leakage test by Amersham:
The source is immersed in water or other suitable liquid at 50°C for 4 hours and the activity in the liquid is measured. Acceptance limit : 0.005 µCi (0.18 kBq).

The contamination test by Amersham:
The source is wiped with a swab or tissue, moistened with methanol or water; the activity removed is measured. Acceptance limit : 0.005 µCi (0.18 kBq).

3.12 Safety Analysis

The isotope used in the tester, Pm-147 is a low energy, low activity, sealed beta point source. The emission of the source is very pure beta only, which is easily absorbed : the beam from the collimator will be absorbed almost totally by an ordinary sheet of cardboard with a basis weight of 300 g/m².

The source is of sealed type and it is encapsulated in a holder/collimator assembly with solid brass all over for at least 2.5 mm in thickness. The source is placed in the tester in such a way that it cannot be accidentally removed (suitable Allen-type key, supplied with the tester, is required for removal of the detector/collimator assembly).

The measuring gap is narrow (height 2 mm) and it is automatically closed by a brass cup, 59 mm in diameter, that is forced down by gravitation. Thus no parts of the human body may have access to the beam. The external radiation as close to the source as possible is very low, even with the gap opened to the full 2 mm.

The operator needs to be at the tester once a shift or once a day only for sample loading which normally takes less than 30 seconds.

The tester is used at a fixed place in paper mill laboratory facilities. At the mills usually few persons only have admittance to these rooms.

The user inserts the beta source to the tester once per 2...3 years according to precise instructions given. The installation is easy and fast: all operations necessary take less than 10 minutes.

The operation and maintenance manual supplied with the

tester contains all necessary radiological safety instructions for the safe operation of the tester as well as for the installation and removal of the source.

A yellow/magenta-coloured warning label is attached to the tester.

LIST OF APPENDIXES :

Appendix A :	The documentation provided along with the Pm-147 beta source by Amersham International, a drawing of the source
Appendix B :	The brochure of the AMBERTEC Beta Formation Tester with the List of References
Appendix C :	Drawing of the collimator/detector assembly
Appendix D :	Drawings of the source holder and collimator with the locknut, the detector collar and the sheet pressing cup.
Appendix E :	The caution label of the device
Appendix F :	Calibration report
Appendix G :	Sample of the documentation accompanying the device

APPENDIX A : THE DOCUMENTATION PROVIDED ALONG WITH THE Pm-147 BETA SOURCE BY AMERSHAM INTERNATIONAL, A DRAWING OF THE SOURCE

Amersham international plc
Amersham Laboratories
White Lion Road Amersham
Buckinghamshire England HP7 9LL

telephone Little Cha[illegible] 04) 4488
cables Activity Amer[illegible]
telex 83141 ACTIVA G

[illegible]dioactive source test report

product code	description	nominal activity	customer
PMCK3556	PROMETHIUM 147 BETA POINT SOURCE E881976	1 111 MEGABQ, 3 MILLICURIE	SONAR OY P O BOX 5 ESPOO 02201 FINLAND
AI item no. N29573	SEALED SOURCE		

BSI/ISO classification *	special form certificate no.	recommended working life		customer's order no.
NOT TESTED	NONE	NOT ASSESSED	005 1	S-55821 01 SONAR

serial number	measurement check	measurement check date	leakage test	date passed	leakage test	date passed	contamination test	date passed
1529BD					L	24 JAN 89	A	25 JAN 89

notes

signed [illegible]

date 27 JAN [illegible]

* this classification complies with BS.5288:1976, which is in agreement with ISO.2919 (see overleaf for definition and description of tests)

Amersham International plc
Amersham Laboratories
White L[illegible] d Amersham
Buckl[illegible] England HP7 9LL

telephone Little Chalfont (024 0[illegible]
cables Activity Amersham telex
telex 83141 ACTIVA G

Pa[illegible]g note

can number	consignment no.	required in despatch warehouse day	date
N29573	890127001	FRIDAY	27 JAN 89
CART.NO.	010307		

goods to

SONAR OY
P O BOX 5
ESP00
02201 FINLAND

method of transport	first transhipment
AIR	
flight or station	second transhipment
AY034	
departure date	arrival date and time
28 JAN 89	29 JAN 89 0210 HRS
departure time	airport or station
2020 HRS	HELSINKI

container	transport index	waybill number
01W1P0P	0.1	10551733765

item number	code number	quantity	description
	FOR SONAR		YOUR ORDER S-55821 01
N29573	PHCK3556	1	111 MEGABQ , 3 MILLICURIE
SOURCE			PROMETHIUM 147 BETA POINT SOURCE E881976
			3 MILLICURIES(NOMINAL) 1.3MM AD IN X110 CAPSULE

Information for internal use

can number	consignment number
N29573	890127001

picking station 005

CARTON NO.010307
stores day and date
FRIDAY
27 JAN 89

method of transport
AIR FINNAIR

documents with package	quantity	type
invoices		
certificates of origin		
consignee road certificate		
address label	1	
can content label	1	
RIA warning label	2	II
carton content label		

flight or station

arrival destination

transport category | container

transport index | code number

waybill number | batch number

transport group

item numbers

Amersham

Quality control

Quality control of radiation sources can be divided into four main parts:

1. Checks made routinely during production

Quality Assurance
Radiation sources are manufactured in accordance with a strict quality assurance programme, details of which can be obtained on request.

Testing for leakage and contamination
Stringent tests for leakage are an essential feature of radioactive sources production. The methods adopted depend on the design and intended application of the source, and also on statutory requirements. Where necessary, tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below. The particular tests used for each type of source are given under the appropriate product entry.

Wipe test A
The source is wiped with a swab or tissue, moistened with methanol or water; the activity removed is measured.
Acceptance limit: 0·005μCi (0·18kBq)
(This test conforms to BS.5288/App.D.2.1).

Wipe test B
The source is wiped with a swab or tissue, moistened with methanol or water; the activity removed is measured.
Acceptance limit: 0·05μCi (1·8kBq).

Bubble test D
The source is immersed in water or a suitable liquid and the pressure reduced to 100mm of mercury (13kPa).
No bubbles must be observed.
(This test conforms to BS.5288/App. D.3.1. and it has been demonstrated that this test is suitable for sources with free volumes greater than $10mm^3$ [Amersham International Technical Report No. 8]).

Immersion test L
The source is immersed in water or other suitable liquid at 50°C for 4 hours and the activity in the liquid measured. Acceptance limit: 0·005μCi (0·18kBq).
(This test conforms to BS.5288/App. D.2.3.).

Immersion test M
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled and rinsed using fresh water. These operations are repeated twice, boiling in the water from the previous rinsing operation. If the activity detected in all the liquid collected is less than 0·005μCi (0·18kBq) the source is considered to be leak-free.
(This test conforms to BS.5288/App. D.2.4.)

Helium leak test H
A mass spectrometer is used to detect helium leakage from sources helium filled prior to welding.
Acceptance limit 10^{-6} mbar l s^{-1}
(This test exceeds the requirement of BS.5288/App. D.3.4)

Helium pressurisation test S
A mass spectrometer is used to detect helium leakage from sources previously pressurised in helium after encapsulation.
Acceptance limit 10^{-6} mbar l s^{-1} for non-leachable solid inserts and 10^{-7} mbar l s^{-1} for all others. (This test exceeds the requirement of BS.5288/App. D.3.5)

Radon emanation test R
The source is immersed in a solution of phosphor in an organic liquid under vacuum; the leakage of radon is measured by liquid scintillation counting.
(DWIGHT, D.J. Radiochemical Centre Report R176).
The acceptance limit corresponds to about 5×10^{-11} Ci per 24 hours (2Bq per 24 hours).
This test exceeds the requirement of BS.5288/App. D.2.6).

Krypton emanation test P
The source is held under reduced pressure for 24 hours. The contents of the chamber is analysed for Krypton by scintillation counting. The test is repeated after at least 7 days. Acceptance limit 0·1μCi (3·7kBq).

2. Special safety performance tests on prototypes

A radiation source must provide highest possible integrity together with minimum attenuation of the required radiation by the encapsulation materials. Safety is always the prime consideration.

Standards for the testing of sealed radioactive sources have been specified by the British Standards Institution in BS.5288. 1976.

This classification system is modelled on USA standard USASI N5.10 which also gives a number of comparable leak test methods.

BS.5288 is in agreement with the following standards produced by the International Organization for Standardization (ISO):

ISO.1677 'Sealed radioactive sources – General'
ISO.2919 'Sealed radioactive sources – Classification'
ISO Technical Report 'Sealed radioactive sources – leak test methods' (ISO/TR.4826 – 1979(E)).

3. Measurements

Each source or batch of sources is checked to ensure that the strengths of the sources supplied are within the limits specified. Wherever possible the results of these checks are indicated on the test report. The methods of specifying the strengths of sources are discussed under the heading specification on page 55 and details are included in the appropriate sections of this catalogue.

4. Test reports

A test report is supplied with each source or batch of sources. Where appropriate the following information is given:
Product code
Product description
Capsule type
ISO classification
Special form certificate
Measurement check
Leakage check
Contamination check

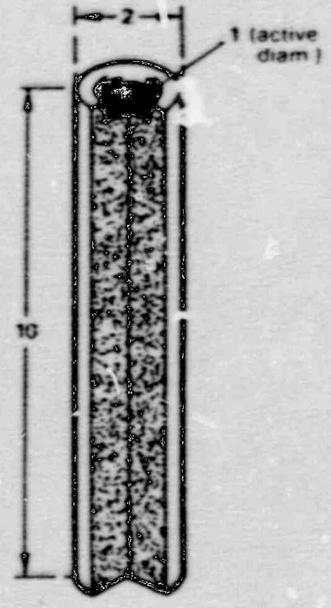
Promethium-147

Beta sources

Point sources

Disc of promethium-147 silver foil mounted in a stainless steel holder, type X.110

X.110



Nominal activity* mCi	mBq	Active diameter mm	Overall diameter mm	Code
~~1~~ 3 ± 30%	~~37~~ 111	1	2	~~PHC 32~~ PHCK 3556

*Tolerance −10, +25%

Availability: within 4 weeks

Recommended working life: ~~5 years~~ Not assessed

Quality Control
Wipe test A
Immersion test L

Beta emission or radionuclide activity is measured using the most suitable detector. Full details are given in the Test Report accompanying the source.

Safety performance testing

Code	ISO classification
~~PHC 32~~	~~C64343~~

The source PHCK 3556 is identical in dimensions with the source shown in the drawing.

Amersham has been delivering these sources since end of 1988.

THE CONSTRUCTION OF THE BETA POINT SOURCE

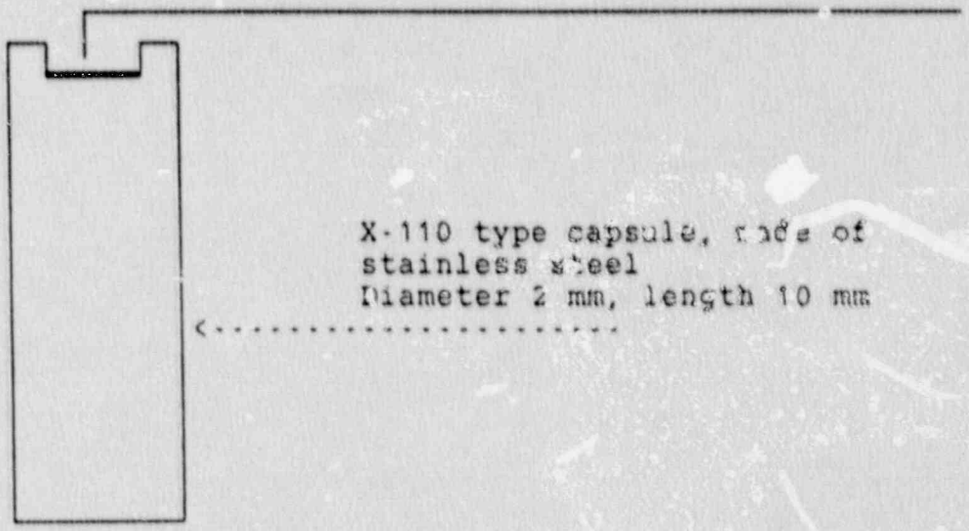
According to information obtained from AMERSHAM International, U.K. the Prometheum-147 point source PHCK 3556 is of following construction :

The prometheum/silver alloy pellett is placed in a capsule made of silver and palladium. The capsule will then be calendered to a desired thickness. For the point source in question a small disc (1.3 mm in diameter) will be punched out and prepared for encapsulation.

Diameter 1.3 mm

Cross section of the source disc.

The source disc will be fastened to a X-110 type capsule, into a small cavity, drilled to the end of the source holder rod.



APPENDIX B : THE BROCHURE OF THE AMBERTEC Beta Formation Tester WITH THE LIST OF REFERENCES

AMBERTEC BETA FORMATION TESTER

the reliable off-line formation tester

Highlights

- Measures true basis weight up to 300 g/m², for any sheet formation or colour
- Single value formation index that is easy to understand and that corresponds well with the visual assessment, as well as with the print results
- Prints out a basis weight histogram and topographic map of basis weight variation
- Fast automatic measurement of multiple sheets or cross-directional sample strips
- Stores data and results on floppy disks
- Easily adjustable measuring parameters with preset default values
- Easy operation; does not require any special skills
- Easy calibration with ordinary paper samples
- Constant precision, independent of the basis weight level
- Radiation safe

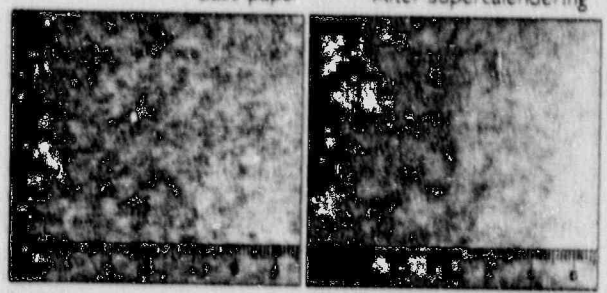
The traditional optical measurement is easily fooled by various factors.

Formation is one of the most important aspects of paper quality as it has an effect on practically all the other properties of paper. Traditionally formation is visually checked by the paper machine crew. To allow comparison of formation - independent of the inspector - the visual impression should be replaced by a measurement that gives numerical values.

All of the commercially available formation testers so far have been based on the optical measurement, trying to imitate the human eye. It is a widely recognized fact, however, that the **optical measurement is easily fooled by a lot of different factors,** always present in the paper manufacturing process.

DIFFERENCE BETWEEN OPTICAL AND BETA MEASUREMENT

Paper grade: SC rotogravure



Std. deviation of basis weight 4.5 g/m² 4.5 g/m²

(Formation remains unchanged in supercalendering but light transmittance increases considerably.)

Based on beta radiation

The **on-line** formation testers are used mainly to adjust the process towards a minimum of basis weight variation. Usually there are minor changes only in the furnish composition and process variables within a paper grade under production. Thus, for on-line applications, the optical measurement is the right choice.

For **off-line** uses formation measurement based on the beta radiation absorbency is superior to the optical measurement in reliability. It is a fact that optical inhomogeneity caused by furnish composition and by process variables does not affect the results of beta-radiation based measurement: thus samples of different paper grades, produced by different processes of different raw materials can be reliably compared. The off-line use also sets much higher requirements on the applicability of the measurement. Furthermore the off-line measurement is used for the absolute values of formation while the on-line measurement is merely used to monitor trends only. **For reliable off-line operation the beta method is the only choice.**

Suitable for all paper grades

Unlike all the other commercially available formation testers the AMBERTEC BETA FORMATION TESTER measures the small scale variation of basis weight (i.e. the formation of paper), independent of any variations in the optical properties of the sheet, caused by furnish composition (fibre, filler, coating) or by process variables (beating, wet pressing, calendering). As the measurement is also independent of the colour of the sheet, it is even possible to measure printed samples, which is totally impossible with the optical formation testers. The AMBERTEC BETA FORMATION TESTERS are being used to measure a variety of paper and board grades within the basis weight range 30...300 g/m^2.

Automatic operation

AMBERTEC BETA FORMATION TESTER has been designed to measure both cross-directional sample strips, cut from a jumbo reel and sample sheets glued together with adhesive tape to form a consecutive sample set. The sheets may vary in length as the tester detects the size of the sheet. Thanks to the automatic operation the tester may be run around the clock without an operator to stand by. After the sample roll has been set into the tester the measurement will be easily started. The tester then automatically carries out measurements until the end of the sample set. Of course it is possible to measure single sheets of paper, too. In the end of the measurement the results are automatically stored on a floppy disk. It is possible to store even the measured basis weight data for further analysis.

Formation index

Standard deviation of basis weight is used as the index for formation. In addition to this the tester prints out the histogram of measured values as well as a topographic map of basis weight variation for each sheet. Finally a summary of the results for each sample set will be printed out! The index corresponds well with printability of paper as well as with visual assessment of formation for many grades of paper.

Stepwise scanning

The operation is based on stepwise scanning of the specimen: during each measurement the specimen is stationary. This gives superior accuracy: the movement or time constants will cause no errors in the results. Also, it allows constant precision of grammage determination over the entire basis weight range. The microprocessor-based specimen scanner is controlled via a serial interface by an IBM PC compatible computer, which is also used to compute and to file the results.

Measuring arrangement

Prometheum 147 is used as the source of beta radiation. There is no radiation outside the formation tester and thus the tester is absolutely harmless to the user. The proper geometry of measurement has been assured through precision machining of the collimator piece.

Calibration

The AMBERTEC BETA FORMATION TESTER is calibrated using ordinary paper sheets over a wide range of basis weight. Calibration assures reliable, precise basis weight measurements. Calibration procedure is easy and may be carried out by the mill personnel. Normally the tester requires recalibration rather seldom (e.g. at the Helsinki University of Technology the tester is calibrated once a year).

Routine measurement

In the preset routine measurement the basis weight is measured at 400 points over an area of 70x70 mm within less than 10 minutes. The measuring aperture is 1 mm in diameter and the spacing between adjacent points is 3.5 mm. The formation index is the standard deviation of basis weight for these 400 measurements.

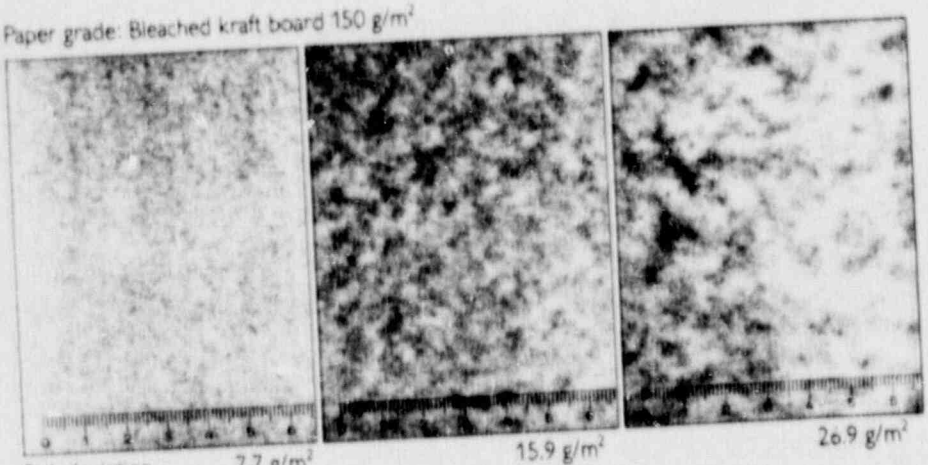
All measuring parameters easily adjustable

In addition to the routine measurement the formation tester may easily be used for other measurements of small scale variation of basis weight as all measuring parameters including step lengths, number of measured values and pulse counting time are easily adjustable over a wide range when required.

Results from various studies show e.g. fair correspondence between formation, strength and printability of paper. Thanks to its reliability the AMBERTEC BETA FORMATION TESTER is the only commercially available tester suitable for the formation guarantee measurements usually connected with paper machine purchases. Scientific publications dealing with the applicability of different formation measuring methods are available through AMBERTEC.

EXAMPLE OF FORMATION MEASUREMENT

Paper grade: Bleached kraft board 150 g/m²



Std. deviation of basis weight: 7.7 g/m² | 15.9 g/m² | 26.9 g/m²

(Resolution of measurement about 0.1 g/m².)

TYPICAL APPLICATIONS

of the Beta Formation Tester comprise

Product quality control, aligned with other automatic laboratory instruments

▼

Product development: reliable measurement of own and competitor's samples – even printed ones

▼

Chemical and fabric suppliers: formation measurements show the performance of the goods offered

Specifications

Measuring aperture:	1 mm in diameter
Movement of specimen:	Stepping scanner (the specimen is stationary during the pulse counting time)
Distance between measuring points:	3.5 mm (default) in both X- and Y-directions (freely selectable in both directions)
Number of points per measurement:	400 pcs (default, selectable)
Precision of basis weight determination:	Constant precision (selectable), basis weight-independent
Basis weight range:	About 20...300 g/m^2
Width of the paper specimen:	210 mm max. (ISO A4-format sheet)
Measuring area:	Selectable; width 70 mm max, length up to the length of the sheet
Source of radiation:	Prometheum-147, sealed point source, with nominal activity of 3 mCi (111 MBq).
Electrical:	110 V/60 Hz or 220 V/50 Hz versions supplied

NOTE! In the use of the tester the local requirements of radiation safety are to be followed. In some countries a license is required, where the names of the personnel in charge of the radiation safety at the mill are stated.

The source is placed in the formation tester in such a way that no radiation will leak outside the measuring gauge. Thus the user will not be exposed to radiation and no personal dosimeter will be necessary.

- Expertise for your benefit -

AMBERTEC

AMBERTEC Oy
P.O. Box 58
02271 Espoo
Finland

Telephone (90) 882 902, (Int.) +358-0-882 902
Telefax (90) 882 963, (Int.) +358-0-882 963

AMBERTEC

February 1990

AMBERTEC Beta Formation Tester

LIST OF REFERENCES:

Testers suitable for measurement of single sheets only :

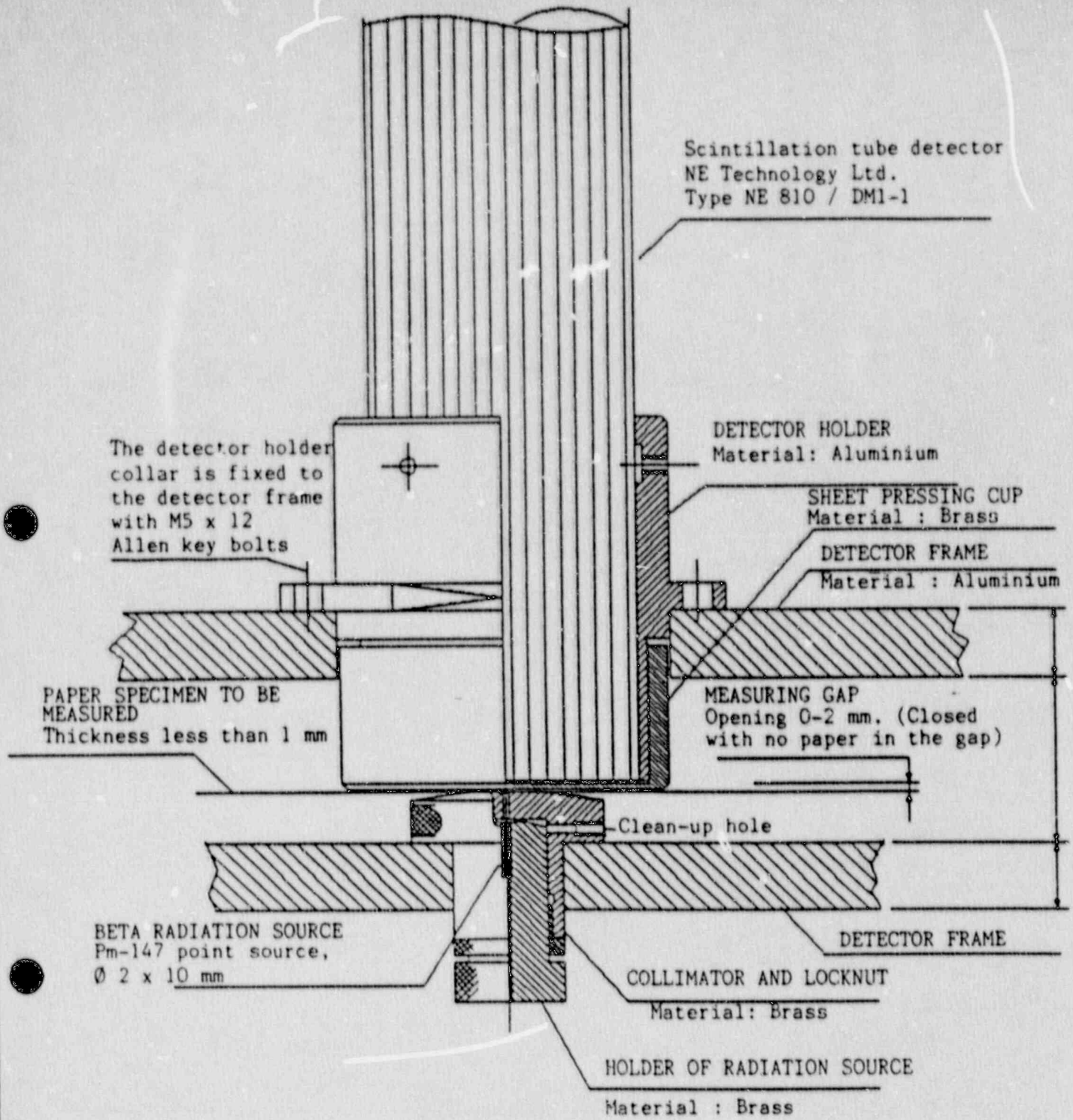
1 Veitsiluoto Oy, Ke ni, Finland
2 Kemira Oy, Vaasa Finland
3 Metsä-Serla Oy, Äänekoski, Finland
4 Finnish Pulp and Paper Research Institute, Helsinki, Finland
5 Tampella Oy, Inkeroinen, Finland
6 Tampella Oy, Tampere, Finland

(Testers of type "Helsinki University of Technology Formation Tester". All except Tampella/Inkeroinen's device have been made by the people behind the new AMBERTEC Beta Formation Tester. Tampella/Inkeroinen's device has been rebuilt by the same personnel.)

Testers suitable for measurement of [a]single sheets, [b]multiple sheets glued together one after another and [c]cross directional sample strips :

	Valmet Paper Machinery, Jyväskylä,	Finland	
1	Helsinki University of Technology,	Finland	1988
2	United Paper Mills, Jämsänkoski,	Finland	1988
3	Korsnäs AB, Gävle,	Sweden	1988
4	Myllykoski Oy, Myllykoski,	Finland	1988
5	Tamfelt Oy Ab, Juankoski,	Finland	1988
6	Kymmene Oy, Lappeenranta,	Finland	1989
7	Valmet-Ahlström Oy, Karhula,	Finland	1989
8	Valmet-Karlstad AB, Karlstad,	Sweden	1989
9	Tampella Oy , Anjala,	Finland	1989
10	Union Camp Corp., Princeton, N.J.,	U.S.A	1989
11	Rauma-Repola Oy, Rauma,	Finland	1989
12	Weyerhaeuser, Tacoma, Washington,	U.S.A.	1989
13	~~Confidential~~ James River, Neenah, WI	U.S.A.	1990

(All above of type AMBERTEC Beta Formation Tester except Valmet/Jyväskylä's device which is of Valmet's own construction. Valmet's device has been made according to the AMBERTEC specifications of measuring geometry and thus gives same results as all of the above AMBERTEC Beta Formation Testers.)



NOTE : ALL DIMENSIONS ARE IN MILLIMETERS

Part nr	Part or assembly name	Drawing and part nr	Texture	Shape, dimensions, model	Pcs
			Material		

Product	Joins to	Mass	Tolerances		Scale	Drawn	
					1 : 1	Chkd.	Ank 69 06 13
						Appd.	Ank 89 06 15

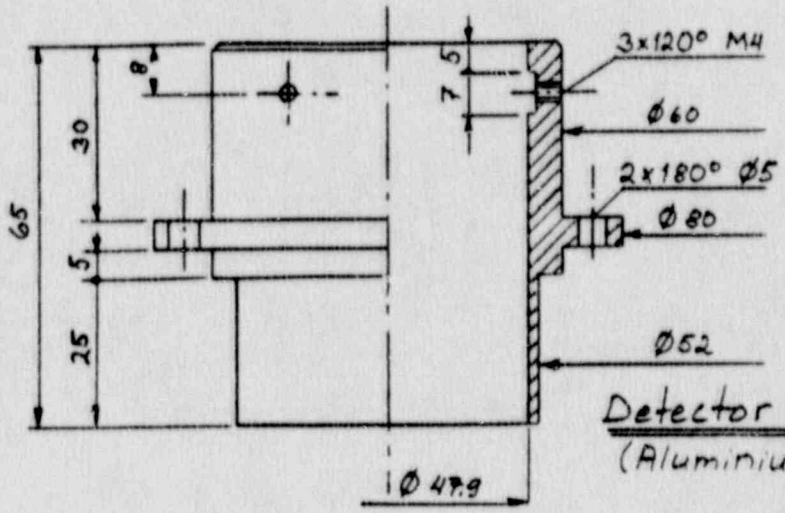
AMBERTEC Oy, Espoo, Finland

AMBERTEC Beta Formation Tester
COLLIMATOR/DETECTOR ASSEMBLY

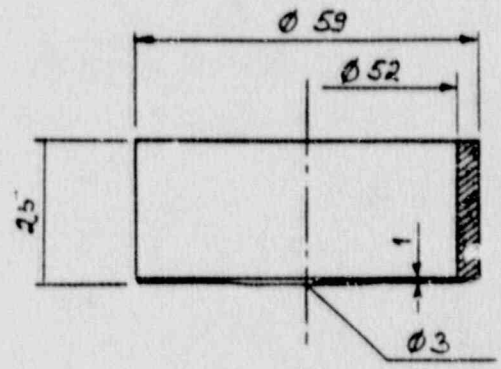
BFT-1/00010

Replaces BFT-1/00005 | Replaced

APPENDIX C : DRAWING OF THE COLLIMATOR/DETECTOR ASSEMBLY



Detector holder
(Aluminium)

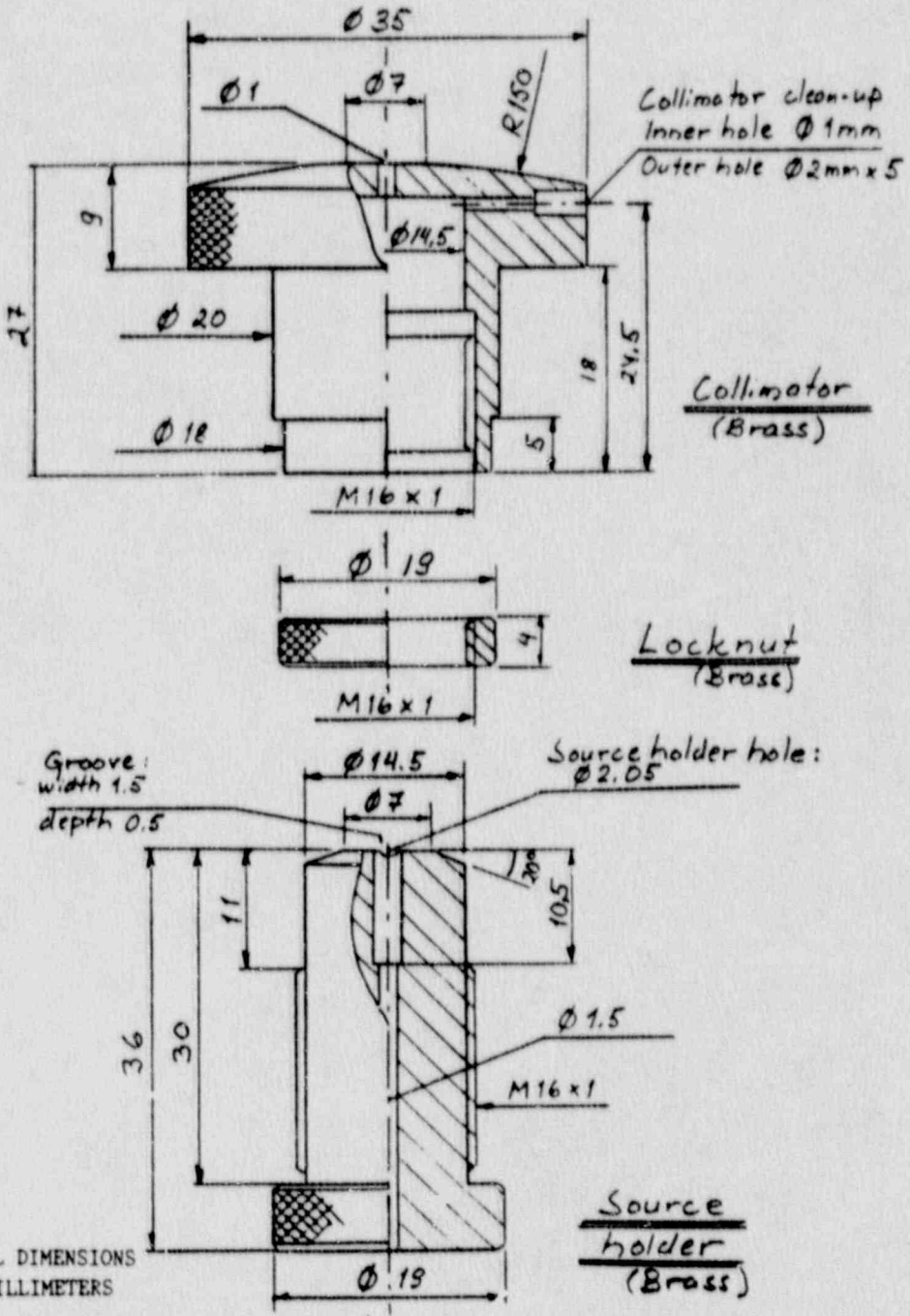


Sheet pressing cup
(Brass)

NOTE : ALL DIMENSIONS ARE IN MILLIMETERS

Sheet pressing cup	Brass	1
Detector holder	Aluminium	1

Part or	Part or assembly name		Drawing and part nr	Texture	Shape, dimensions, model		Pcs
					Material		
Product	Items to	Mass	Tolerances		Scale	Drawn	
					1 : 1	Chkd.	
						Appd.	
	AMBERTEC Oy, Espoo, Finland				BFT-1/ 00011		
	AMBERTEC Beta Formation Tester DETECTOR HOLDER ASSEMBLY				Replaces	Replaces	



NOTE: ALL DIMENSIONS
ARE IN MILLIMETERS

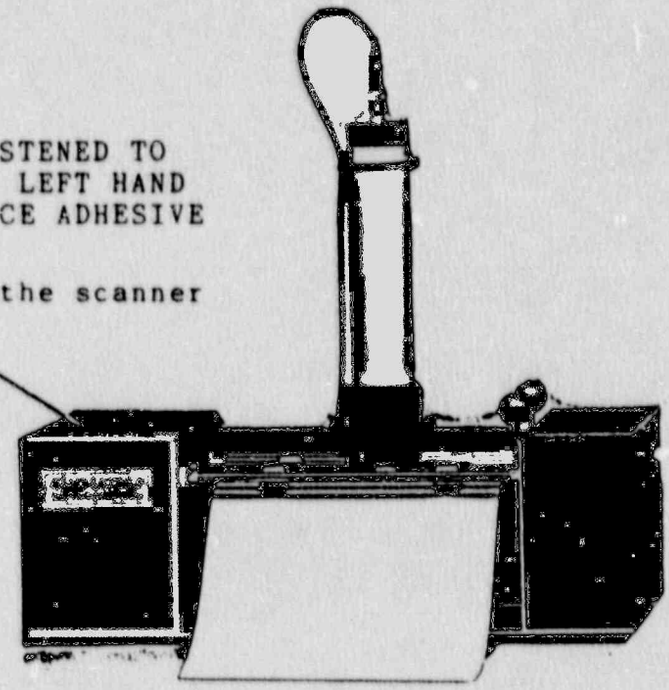
Part or	Part or assembly name		Drawing and part nr	Texture	Shape, dimensions, model material		Pcs
Product	Items to	Mass	Tolerances		Scale 2 : 1	Drawn	
						Check	
						Appd	
	AMBERTEC Oy, Espoo, Finland				BFT-1/ 00012		
	AMBERTEC Beta Formation Tester SOURCE HOLDER/COLLIMATOR ASSEMBLY				Replaces	Replaced	

APPENDIX D : DRAWINGS OF THE SOURCE HOLDER AND COLLIMATOR WITH THE LOCKNUT, THE DETECTOR COLLAR AND THE SHEET PRESSING CUP.

APPENDIX E : THE CAUTION LABEL OF THE DEVICE

THE LEXAN LABEL IS FASTENED TO THE UPPER SIDE OF THE LEFT HAND COVER USING DOUBLE FACE ADHESIVE TAPE.

The label is only at the scanner unit (in figure)

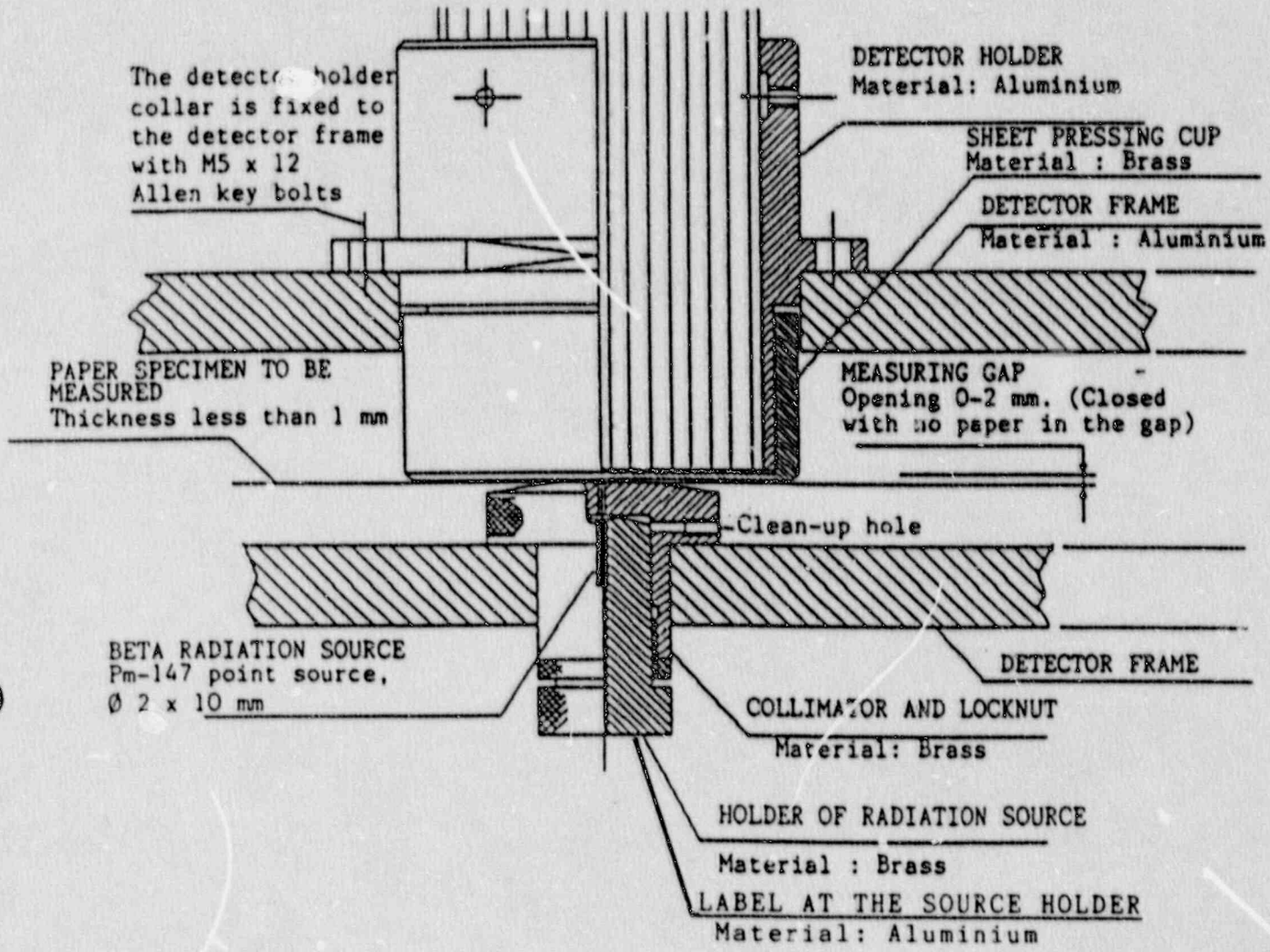


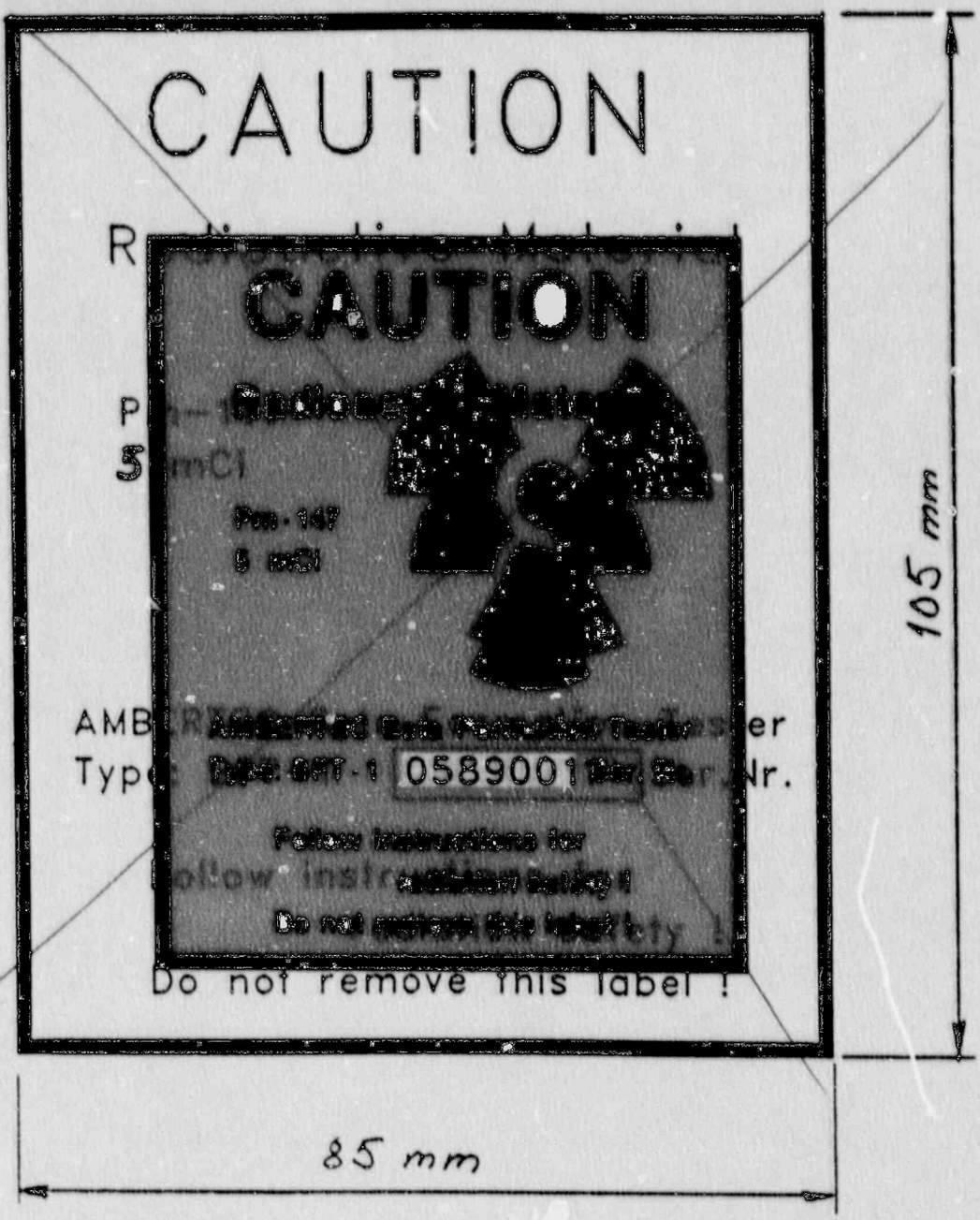
LABEL AT THER SOURCE HOLDER

Engraved in aluminium (anodised, black text)
Shown left in natural size.

The label is epoxy cemented onto the lower end of the source holder.

190 MBq equals to 5 mCi (=exactly 185 MBq)





LABEL OF THE TESTER

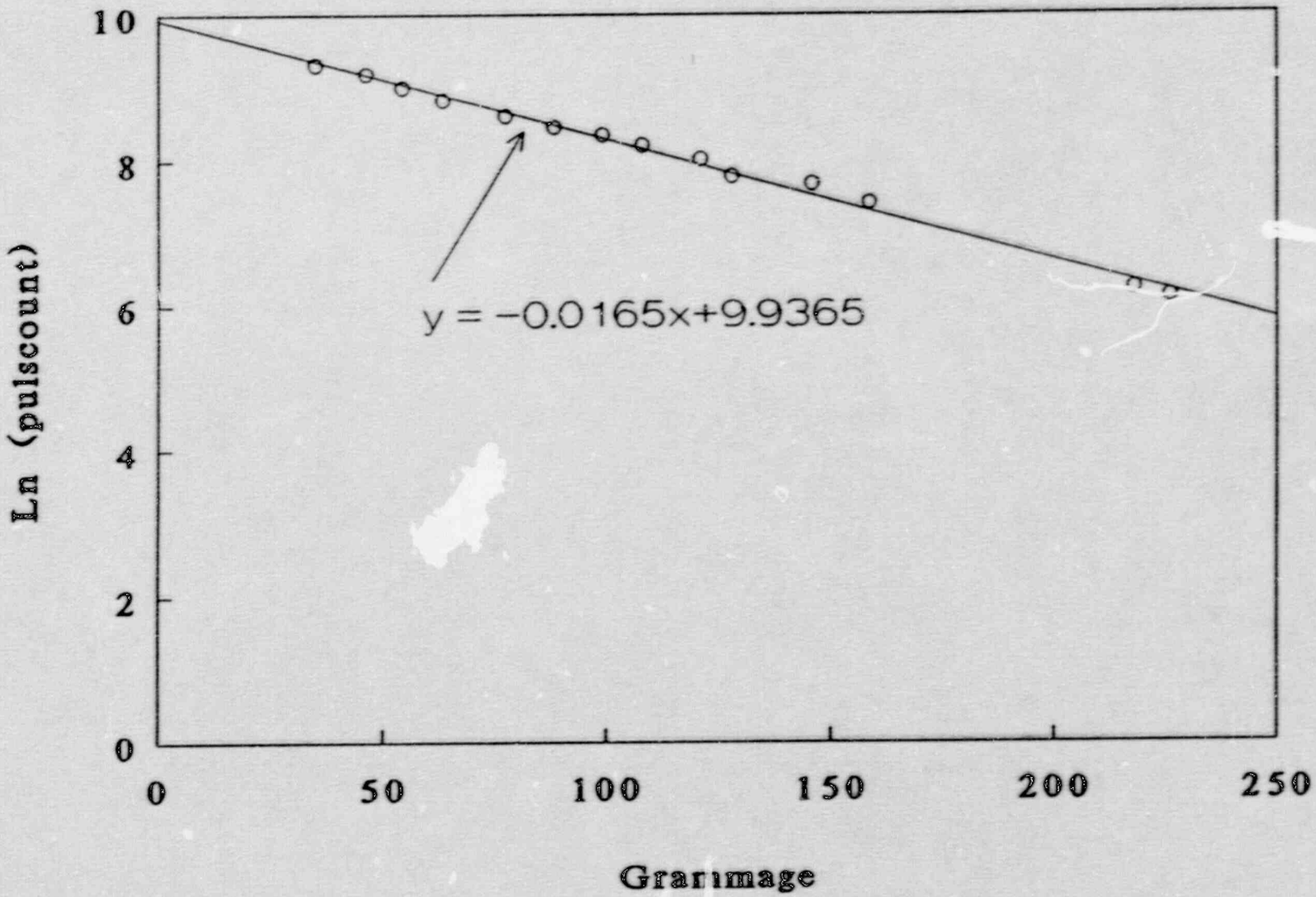
Material LEXAN-plastics, yellow background, magenta text. Label will be fastened at the left cover of the specimen scanner unit using a special double face adhesive tape.

The date-field is missing from the label as the source will be replaced quite often (every 2.5 years) thus making it necessary to amend the label if the information were on the label.

APPENDIX F : CALIBRATION REPORT

AMBERTEC Beta Formation Tester

Calibration chart



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AMBERTEC

AMBERTEC Beta Formation Tester

CALIBRATION TEST REPORT
Standard sheet set

Date : 7.12.1988

Measured by : P. Falkman

Client : Myllykoski Oy

Serial N:r : 1288006A

N:r	Grammage	T	N	Std.dev.
418	18			
410	25			
302	35	1	11069	3.35
109	46	1	9793	4.45
119	54	1	8110	4.40
101	63	1	6813	4.63
127	77	1	5469	2.74
214	88	1	4687	6.19
203	99	1	4196	2.08
509	108	1	3642	8.83
217	121	1	3029	5.55
428	128	1	2408	6.19
511	146	2	2164	11.86
402	159	2	1668	10.22
513	218	3	506	6.59
507	226	3	449	15.79
501	245			
515	270			
505	332			

Absorption coefficient : 0.01655

HV potentiometer setting 390 (equals to 780 V)

AMBERTEC

AMBERTEC Beta Formation Tester

CHECKLIST : ASSEMBLY AND FUNCTIONS

Serial number : 1288 006

Client : Myllykoski Oy

		Date	Inspect.
CONTROL UNIT : Assembly		1.12	Duk
Scaler ST 7 :	Serial nr.	012	
Detector DM1-1	Serial nr.	3239	
ROBCON CPU 019 311	Serial nr.	4698	

SPECIMEN SCANNER UNIT :		
Locking of drive wheels	ok	Duk
Drive belt tension	ok	Duk
Sample spool brake	ok	Duk
Sample spool lock	ok	Duk
Pressure roller adjustments	ok	Duk
Adjustment of measuring gap	ok	Duk
X-directional movement	ok	Duk
Y-directional movement	ok	Duk
Operation: manual drive switches	ok	Duk
Operation: limit switches	ok	Duk
Operation: pressure roller switches	ok	Duk

FUNCTIONS:		
Zero flux determination	ok	TP
Calibration (separate dodument)		TP
Routine scanning pattern	ok	TP
Measurement: single sheets	ok	TP
Measurement: multiple sheet set	ok	TP
Measurement: CD-strip	ok	TP
PACKAGING :		

2. CONTROLS AND CONNECTORS

(NOTE: If a computer or a matrix printer, not delivered by AMBERTEC is used the connectors might be different from those described below.)

A. SPECIMEN SCANNER (rear panel)

1. Scanner control cable (connector D-37 M)
2. Manual operation switches for X- and Y-directional movement
3. Scintillation detector cable (BNC-connector)

B. CONTROL UNIT BOX

Front panel:

1. Scintillation detector cable PROBE (BNC-connector)
2. High voltage adjustment potentiometer H.V. ADJUST 0-2000 V
   (NOTE: the potentiometer setting runs in the range 0-1000 showing A HALF OF THE ACTUAL HIGH VOLTAGE ADJUSTED!)
3. High voltage selector switch (Choose position SC)

Rear panel:

4. Scanner control cable (connector D-37 M)
5. Serial interface cable (connector D-25 M, or D-9 M)
6. Formation tester mains switch
7. AC connector (IEC)

C. COMPUTER (Rear panel:)

1. Mains switch (right side wall, rear edge)
2. AC connector
3. AC outled for monitor screen
4. Monitor screen mains switch (Under the screen, front)
5. Monitor videosignal (connector D-9 F)
6. Printer cable connector (LPT1, Centronics, connector D-25 F)
7. Formaation tester control (serial connector COM 1, D-9 M) (optionally D-25 M connector)
8. Connection to external (mill) computer (optional, COM 2, connector D-25 M)
9. Keyboard connector (DIN-connector)

D. MATRIX PRINTER

1. Mains switch (front left)
2. Mains cord
3. Printer control cable (rigt side, Centronics, R-36-connector)

FUSES

1. Control unit power supply fuse, 5A/250V (inside the power supply case)
2. Scalerin fuse (inside control unit box, scaler front panel, right) (T63mA/250V)
3. Computer power supply fuse, 5A/250V (inside the power supply case)

Whenever a fuse blows it is a symptom of some malfunction or defect in the apparatus. Before you replace the fuse the possible defect must be detected and repaired.

NOTE : **If you use a computer or a matrix printer not supplied by AMBERTEC the information on fuses must be checked in the manuals of these equipment.**

3. CONNECTION OF THE TESTER COMPONENTS

3. CONNECTION OF THE TESTER COMPONENTS

AMBERTEC Beta Formation Tester must be connected as follows:
(NOTE: If the computer and the printer are not supplied by AMBERTEC the connectors may vary from these specifications. Check the manuals of these equipment.)

1. ALTERNATIVE A:
The tester requires the minimum space at the table if only the specimen scanner, monitor screen, keyboard and printer are at the table and the computer and the control unit box are placed on shelves under the table. There must be a free air circulation for adequate ventilation for the computer. Installed in this way the tester requires a table of about 120 x 60 cm.

   ALTERNATIVE B:
Place the specimen scanner and the control unit box onto the table such that the scanner will be on the right side if the control unit. Place the computer on the left side of the control unit, the monitor screen on top of the computer and the keyboard in front of the computer. Place the matrix printer onto the left side of the computer. In this way the tester requires a table of about 200 x 60 cm.

2. Connect the scanner to the control unit as follows (see the codes for connectors in this manual, section 2):

   a. Connect the scanner control cable (both ends with D-37 F connector) to the scanner connector A1 and to the control unit connector B4.
   b. Connect the scintillation detector cable kaapeli to the control unit connector B1 (PROBE) and to the end of the detector A3.

3. Connect the control unit to the computer with the serial interface cable (the D-9 F connector to the control unit box and the D-25 F connector to the computer, use the D9/D25 adapter supplied with the tester if required): computer connector C7 (=serial interface COM 1) and control unit connector B5.

4. Connect the computer and the matrix printer using the Centronics cable (D-25 M and R36-connectors): computer connector C6 (LPT1) and printer connector D3.

5. Connect the keyboard to the computer connector C9 (DIN).

6. Connect the monitor screen power supply cord to the computer connector C3 and the video signal cable to connector C5.

7. Connect the power supply cords to the control unit connector B7, computer connector C2 and matrix printer connector D2.

8. Check that the mains switches of the control unit, computer and printer are in OFF position.

9. Connect the power supply cords into AC outlets with protective grounding. The tester is now ready for operation according to the section 5 in this manual.

4. FUNCTIONAL DESCRIPTION

4. FUNCTIONAL DESCRIPTION

Background

Formation of paper is the measure for the planar distribution of material in a small scale in the paper sheet. The scale refers to wavelengths of variation usually less than 100 mm.

There are two alternative methods for measuring of formation: the direct and the indirect beta absorption methods. In the latter a beta radiogram is first exposed to a x-ray film using beta radiation of adequate energy level and the radiogram is then measured optically. This methods is superior in resolution but is extremely slow and laborous and thus very inconvenient for routine use. Both methods may be calibrated to directly output true values of grammage variation.

The optical measurement of paper formation (i.e. grammage variation in a small scale) as a matter of fact is the very same method that the machine tender is using when inspecting the sheet against transmitted light. It is extremely difficult to calibrate the results of the optical measuremen to true grammage as the transmittance of light in paper does not depend on grammage only but on various other parameters affecting the optical behaviour of the sheet. Such parameters include the furnish composition (fibrous components, filler type and the amount of filler, coating colour type and the amount of coat, colour, optical brighteners) as well as many process variables (beating of pulp, wet pressing, machine- and supercalendering). Usually optical formation testers do not incorporate a calibration procedure - or the possible calibration is done beyond the actual measuring range that then is extrapolated for the range in use. No calibration procedure in optical testers will be able to remove the effect of the process variables on the results; nor will it be able to remove the effect of uneven distribution of furnish components in the sheet. Thus the optical method is not suitable for off-line formation measurement in which usually different types of samples (of different grades, made in different paper machines with different furnish compositions) are measured and compared. The optical measurement of formation on the other hand extremely well suits for on-line measurement and optimization of formation, usually within a single grade of paper, with furnish and process parameters kept as constant as possible.

It is of course possible to determine the small scale variation of grammage gravimetrically, weighing small pieces of paper with a balance, sensitive enough. However, as the size of the specimen to be measured will be decreased to the level necessary in the measurement of formation it is practically impossible to obtain values of grammage precise enough for calculation of formation indices.

To allow the measurement of formation (small scale distribution of grammage) the size of measuring aperture as well as the measured area at the specimen must fulfill certain requirements. The size of the measuring aperture affects the resolution of grammage variation: a grammage value in fact is the mean value

of grammage variation over the area of the aperture. (Think the weighing of a specimen with a balance: as you weigh the specimen of a certain area (= aperture) you will only get a single value, i.e. the mean of grammage over the area of the specimen.) Thus, the greater the measuring aperture, the smaller will be the resolution of grammage variation. The use of a large aperture then yields smaller numerical values of grammage variation due to the averaging of the variation over the area of the aperture. Of course, the true variation of grammage in the sheet will not be affected by the measuring principle or by the size of the aperture but the indices of formation might then give a false impression of the issue.

In practice the stochastic nature of beta radiation limits the smallest size of the measuring aperture: it will be impractical to use an aperture smaller than 1 mm in diameter as the error caused by the stochasticity of the radiation gets too high when using a reasonably short pulse counting time. Over the years the aperture size of 1 mm in diameter has been proved to be a fair 'standard size' in various studies also as the results obtained using that aperture size pretty well correlate with the visual ranking as well as with the printing result (some optical testers do use a smaller aperture).

The effect of the area measured also largely affects the results: formation measurement should be able to distinguish between the small scale and the large scale variation of grammage. As a results of empirical studies over many years the optimal area for one measurement of formation has been proven to be 70 x 70 mm² (Sara, H. : The characterization and measurement of paper formation with standard deviation and power spectrum. Helsinki 1978, Helsinki University of Technology, dissertation, 162 p.).

Method of the measurement

AMBERTEC Beta Formation Tester is based on the direct measurement of beta radiation absorbancy. The source of beta radiation (Prometium - 147 -isotope, nominal activity ranging between 1 and 8 mCi) is placed under the sheet and a scintillation counter detentor is on the other side of the sheet. The radiation is led to the sheet through a brass collimator, 1 mm in diameter, length 2.5 mm.

The sheet to be measured will be pressed against the collimator by a heavy brass pressing cup to ensure that the underside if the sheet always lies against the collimator This is to ensure that the measuring geometry is the same from point to point. There is a collimator aperture also in the pressing cup, however with a larger aperture (3 mm in diameter). The cup then lets also such particles to the detector that possibly have been slightly scattered aside when passing through the sheet.

The specimen to be measured will be moved step by step in the measuring gap; thanks to the stepwise scanning the specimen always is stationary during the actual measurement (pulse counting). Thus the possible errors by time constants et.c. will be eliminated and the pulse counting time per point will be freely selectable. Thanks to the latter it is also possible to measure

board samples as it is possible to obtain adequate precision of measurement by increase of the pulse counting time. It is possible to measure boards up to 300 g/m2 in grammage.

For the pulse counting time usually 1 s per point is used. The area measured usually is 70 x 70 mm^2 covered by 400 points. The distance between adjacent points is 3.5 mm in both (X- and Y-) directions. The pulse counting time as well as the measuring parameters may be changed easily according to the user. (NOTE: as the distance between adjacent points usually is 3.5 mm a point then represents a square with side length of 3,5 mm on the specimen. The point lies in the middle of the square. The formation tester software prints out the area of a rectangle that can be drawn along the outmost points of the area. In the routine measurement with 400 measured points using the distance of 3,5 mm between adjacent points this area is 66,5 x 66,5 mm^2.)

The main computer controls the pulse counting from the scaler. The pulse readings at each point are stored in the computer memory for calculations. The computer also controls the specimen scanning automatically after the operator starts the system.

A each point the counted pulse (beta particle) readings will be converted to values of true grammage according to formula below:

$$m_i = M - (1/\mu) \cdot \log (n_i/N) \qquad (1)$$

where

m_i	=	a grammage value
M	=	average (weighed) grammage of the sheet
μ	=	Absorption coefficient of beta radiation
n_i	=	a pulse count reading
N	=	the mean of transmitted pulses throug the sheet

The numerical value of the absorption coefficient of beta radiation in paper to som extent depends on the level of grammage of the sheet. Due to this it is recommended that the absorption coeficient should be determined empirically (see section F. CALIBRATION OF THE TESTER).

As it is not necessary to carry the average of grammage of the specimen (that actually has been determined by the operator) with during the calculations the formation tester software does calculate the indices for formation according to the following manner:

At first the standard deviation for the variation of grammage will be calculated:

For the calculation of the std. deviation the square sum of differences will be first calculated. Using normalized data (i.e. the mean of data is zero; in the formula (1) the divider is the mean of pulses gone through the specimen) the formula may be modified as follows.

$$c' = \sum_{i=1}^{k} (\log(n_i/N))^2 \qquad (2)$$

in which
c' = square sum of logarithms of pulse count transmittance values
n_i = pulse count value, i= 1...k
N = mean of pulse counts through the specimen
k = number of observations (points)

At this stage it is not necessary to carry the absorption coefficient along with the calculations as the standard deviation may be easily converted to grammage at the end of the calculations.

The standard deviation of the logarithmic transmittance of beta radiation will be calculated as follows:

$$\sigma_T = \sqrt{c'/(k-1)} \qquad (3)$$

in which
σ_T = std deviation
c' = square sum
k = number of observations (points).

In the next step likely errors will be removed from the measured data. This will be done by removing observations that differ more than 4 x std. deviation from the mean (=0). This kind of deviations (peaks) that simultaneously would not be defects (shives, holes or measurement errors) are statistically very unlikely in real paper.

In the printout also the number of observations differing more than three times the standard deviation from the mean will be given. These observations however will be included in the calculation.

The peaks, i.e. observations differing more than four times std. deviation from the mean will be removed from the calculated square sum of logarithmic transmittance, from the sum on pulses through the specimen and from the number of observations. For the corrected data a new std. deviation will be calculated and this will be converted to grammage by division with the absorption coefficien[illegible] beta radiation.

$$\sigma_m = \frac{\sqrt{c'/(k-1)}}{\mu} \qquad (4)$$

in which
σ_m = std. deviation of grammage
c' = corrected square sum of logarithmic transmittance of beta radiation
k = corrected number of observations
μ = empirically determined absorption coefficient for beta radiation.

The standard deviation of grammage obtained using the above method is used as the index for formation of paper. It is to note that up to this point the average (weighed) value of grammage, given by the operator, has not been used for anything. **Therefore it is not necessary to know the exact grammage of the sheet at the moment of the measurement;** then however, the other indices, derived from the formation index using the average of grammage (i.e. the normalized formation index and the coefficient of variation) will be incorrect.

It is to be seen in the formula (4) that the results are also correctable if a wrong absorption coefficient of beta radiation has been used in the measurement. This can be done by multiplying the formation index by the ratio of the wrong and the right value of the absorption coefficient.

> As the variation of beta radiation transmittance will be calibrated to grammage using the absorption coefficient, it is essential to empirically determine and to periodically check the value of the coefficient to obtain reliable results.

Traditionally the coefficient of variation has also been used as the index for formation:

$$F_1 = 100 \cdot (\sigma_m / M) \qquad (5)$$

in which

F_1 = coefficient of grammage variation measured using an aperture of 1 mm in diameter
σ_m = std. deviation of grammage
M = (weighed) average of grammage. The tester only measures the variation of grammage.

As there is no clear linear physical correspondence between formation and the level (i.e. the mean) of grammage THE USE OF THE COEFFICIENT OF VARIATION IS NOT RECOMMENDED as the index of formation.

Within a limited range of grammage there is a linear correspondence to be found between the mean and the variance of grammage. Therefore it is possible to obtain comparable results for formation (within a limited range, say 30...50 g/m^2) by division of the standard deviation of grammage by the square root of the mean of grammage.

$$\sigma_{unit} = \sigma_m / \sqrt{M} \qquad (6)$$

jossa

σ_{unit} = the formation of a sheet with unit grammage (1 g/m^2)
σ_m = std. deviation of grammage
M = the (weighed) average of grammage.

Comparison of formation results

Formation indices for papers at equal level of grammage may be directly compared without any difficulties. The comparison of results for samples at different levels of grammage, however, is not as easy.

In measurements of paper technology it is a common practice to normalize the various measured values by division with the mean of grammage to obtain comparable results, independent of the grammage of the sheet. There should be a sound, unambiguous theoretical basis for such a normalization: the results must be dependable on the level of grammage.

There is no linear physical correspondence between the mean and the standard deviation (this could be [illegible] at the paper machine: one is able to produce far better fo[illegible]t the same level of grammage using different skills, [illegible] and machinery). Therefore the coefficient of variat[illegible]ugh printed out in the results as a matter of record o[illegible]y) should not be used in such comparisons. All comparisons between different levels o[illegible] grammage should be done using the normalized index of formatio[illegible] i.e. by division of the std. deviation by the square root of th[illegible] grammage (see above).

Formation guarantee measurements

Whenever the formation of two samples are to be compared in situations which may have juridical consequences (e.g. in formation guarantee measurements usually connected to paper machine purchases etc.) it is the advantage of all parties to measure **both samples simultaneously using the same tester and same calibration.** This is to avoid possible errors which might be present when e.g. accidenatily using different calibration for the different samples.

Usually the samples will not be available simultaneously (e.g. if the reference sample is taken before the rebuild of the machine or from another machine, before the guarantee test sample will be available). **Then the samples should preferably be stored in closed plastic bags in a safe sheltered place up to the moment it is possible to carry out the measurements simultaneously.** The possible yellowing of the samples does not affect the grammage distribution of the sample neither the formation results obtained using the AMBERTEC Beta Formation Tester.

The same applies - of course - to ALL OTHER GUARANTEE MEASUREMENTS whenever the measuring instruments are calibrable or do have settings (time constants, sample moving speeds etc.) that could affect the results obtained.

Precision and accuracy of the measurement

The formation measurement based on beta radiation technique is very accurate: the beta radiation transmittance very accurately depends on the mass (grammage) of the specimen only whereas in the optical measurement the optical transmittance of the sheet depends besides the grammage on various other parameters of the furnish too (fibre and filler type, colour) and of the process (beating, wet pressing, machine and supercalendering).

The precision of grammage measurement may be approximated as follows :

$$\text{Precision of a grammage value} = 100 \sqrt{n} / n$$

in which
n = pulse count at a point (number of transmitted beta particles through the sheet),

If e.g. 10 000 pulses were measured at a point the precision of the grammage determination is approximately

$$100 \cdot \sqrt{10000} / 10000 \text{ , that is : 1 per cent}$$

In the formation tester printout the average beta pulse flux (i.e. the average number of beta pulses per second transmitted through the specimen) is given. The number of transmitted pulses per point may be obtained through multiplication of the pulse flux value with the pulse counting time (the power-up value of the pulse counting time is 1 second).

Sampling

The sample sheets for formation measurement must be chosen in such a manner that the sheet properly represent the lot of paper studied.

Normally the formation of a sample will be determined as a mean of several determinations (sheets) for each sample. According to a thumb rule at least four (4) but preferably nine (9) determinations (sheets) per sample should be done for a reliable result.

Formation, as well as all other properties of paper, does have a cross directional profile. Because of this the sample sheets should be cut out from different positions along the width of the web, if only possible.

As the formation of paper usually varies across the width of the web (i.e. in cross machine direction) as well as in the machine direction it is more sensible to measure the formation from several different sheets than to try to determine the formation from few sheets only trying to increase the number of points per determination or the pulse counting time per point. (This is analogical with e.g.the measurement of the average thickness of the sheet: the result will be more reliable if measured from

various points of the sheet than if measured from few points only with great precision).

The repeatibility of results

In repeated determinations it is not possible to obtain precisely same numerical values of formation. This is partly due to the stochastic nature of beta radiation (the pulse counting time is relatively short) and partly due to the fact that in repeated measurements it is not possible to carry out the determinations at exactly the same points of the specimen. This, however, does not greatly affect the index of formation. The sampling has an effect, far greater to the results.

Typically the formation of a sample, expressed as the mean of std. deviation of grammage from 4...9 determinations is fairly well repeatable: about 0.1-0.2 g/m^2 depending on how well one succeeds to carry out the measurements from exactly the same points of the sheets. The repeatibility of the beta formation measurement has been determined using a tester aimed for measurement of single sheets only; in that tester it is possible to place the sheet every time repeatably in the same position.

How to express the results

The formation of a sample is to be expressed as the mean of the determinations carried out from 4...9 determinations of the sample. Standard deviation of grammage is to be used as the index for formation.

In the formation tester printout the std. deviation of grammage is given using two decimals. In the default routine measurement (400 measured points per determination) only the difference of about 0.2 g/m^2 or more may be considered to be significant. Because of this the formation index for a sample should be given using one decimal only.

That is: if the difference between two indices of formation is less than the above limit the formation of the samples should be considered as equal.

The actual limit of significance depends on the number of parallel determinations per sample and it is relatively easy to obtain through calculation of the confidence limit according to the t (student) distribution; i.e. according to the commonly used statistical check in paper technological measurements.

5. OPERATIONAL INSTRUCTIONS

How to prepare the sample
How to set the sample in the tester
Preparation of the tester
Changing the default parameters
Formation measurement
How to pause the measurement
At the end of the measurement
Zero flux determination

5. OPERATIONAL INSTRUCTIONS

HOW TO PREPARE THE SAMPLE

The width of the sample to be measured must not exceed 210 mm (the width of DIN A4 format sheet). It is possible to measure both 'cross directional' strips (i.e. strips cut from top of a PM jumbo roll) as well as separate sheets. he sheets may be measured one at a time but usually it will be more sensible to prepare a continuous sample set by gluing single sheets together, one after another, using adhesive tape. Then the tester will carry out the measurement of the entire sample set automatically without the need of supervision by the operator.

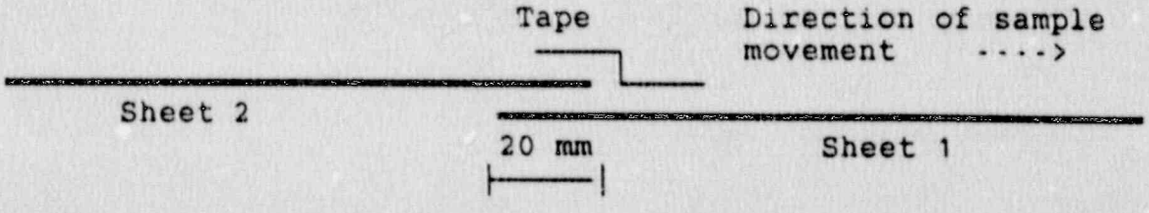
For the measurement of cross directional strip the strip (that has been trimmed to proper width) is to be wrapped around the sample spool. There is a slot in the spool shell provided for the end of the sample strip for easy wrapping.

Wrap the strip around the spool as follows: take the sample spool into your hand in such a way that the brake disk (the thicker end of the spool shaft) points out to the left. Thread the end of the sample strip to the slot of the spool shell and wrap the strip around the shell by rotating the spool clockwise (in the tester the sample strip should unwind from the underside of the spool for proper run (guide) of the strip in the tester.

If the sample is very stiff (thicker boards) it is not worth trying to wrap the sample around the spool - as it will be very difficult to unwind the deformed sample in the tester. Then it is possible to carry out the measurement by placing the sample loosely onto the floor and by threading the sample through the tester from the underside of the empty sample spool set into the tester.

Single sheets may be measured one at a time. Stiff board sheets are easy to be measured one at a time only.

The continuous sample sheet set will be easiest prepared as follows: fasten a ruler (or narrow plate) to the edge of a table using screws or double faced tape. The edge of the ruler must be at least 5 mm above the table surface. Place the DIN A4-format sheet (the length of the sheet may vary, it must, however, be at least 18 cm long) onto the table, the long side against the ruler. Place a weight onto the sheet to prevent it from moving. Place the next sheet after the first one in such a way (see figure below) that the ends of the sheets will overlap about 20 mm. Place the adhesive tape onto the edge of the sheet according to the figure below. Continue preparation until the entire sample set is ready.



Press the tape with your fingers tightly to the sheets to ensure that the sample will not break apart during the measurement.

Wrap the strip around the spool as follows: take the sample spool into your hand in such a way that the brake disk (the thicker end of the spool shaft) points out to the left. Turn the sample set upside down such that the tapes face down. Thread the end of the last sheet to the slot of the spool shell and wrap the strip around the shell by rotating the spool clockwise (in the tester the sample strip should unwind from the underside of the spool for proper run (guide) of the strip in the tester. Stiff samples should, however, be wrapped **counterclockwise** (in the tester the sample strip should unwind from the topside of the spool for proper run (guide) of the strip in the tester) because the stiff sheet may lift the sheet pressing cup (with the sheet) from the collimator and cause measurement error due to changed measuring geometry.

HOW TO SET THE SAMPLE INTO THE TESTER

Standing at the right side of the tester place the sample spool behind the tester such that the brake disk (the thicker end of the spool shaft) points out to you. Thin, flexible samples should be wrapped in such a way that the sample unwinds from the underside of the spool. A stiff sample may wrapped such that it unwinds from the topside of the spool or it may be left loosely onto the floor behind the tester.

Unwind the sample about 40 cm long. Take a grip to the sheet with your right hand such that it bends slightly channelwise (making the strip behave stiffer) for easier threading of the sample. Lift the sheet pressing rollers up with the levers (black knobs) on the right side of the detector frame. Lifting the sheet pressing cup up with your left hand fingers thread the sample through the measuring gap and under the sheet pressing rollers.

Pull the sample forward just a bit and lift the sample spool to its place at the rear side of the tester. Move down the rear sheet pressing rollers using the rear lever. Simultaneously the spool will be locked into its place and the spool brake automatically engages. Draw the sample slightly with your left hand and move down the front sheet pressing rollers using the front lever.

PREPARATION OF THE TESTER

1. DO NOT SWITCH THE POWER ON, YET.

2. Check that all cables of the tester have been properly connected (according to the section 3.)

3. Check that the high voltage of the scaler has been set to zero (0) with the high voltage setting potentiometer and that the high voltage selector switch has been set to position SC.

4. Switch power on to the control unit box (switch at the rear right corner of the box).

5. Set the high voltage according to the value given in the calibration sheet delivered with the tester. NOTE THAT THE ACTUAL HIGH VOLTAGE IS ABOUT TWICE THE READING OF THE POTENTIOMETER (I.E. THE SETTING 500 EQUALS TO ABOUT 1000 V).

   Lock the high voltage setting potentiometer with the lever at the right side of the knob to prevent accidental resetting of the high voltage.

6. Switch power on to the matrix printer (in the STAR LC-10 -print- the mains switch is at the front panel, left side).

7. Switch power on to the computer (in IBM compatible computers the mains switch usually is at the rear right corner of the box). Check that the VDU monitor power also has been set on (usually there is a signal lamp at the monitor.

   If you are using a computer delivered by AMBERTEC Oy the Beta Formation Tester software will automatically be loaded to memory from the hard disk and the tester will be ready for use in a couple of minutes.

   If you are using a computer without a hard disk drive the program disk must be inserted to the drive A: (see the manual of the computer) before the power will be set on. Having switched the power on the program will automatically be loaded intio the computer memory and the tester will be ready for use in a couple of minutes

8. All necessary instructions will be given on the monitor screen. All functions will be chosen from menu windows appearing to the screen. Choose a function by moving the light bar to the desired function (using the up and down arrow keys) and by pressing the Enter key.

   There is a brief help screen available for each of the functions of the tester. (Choose the HELP function).

CHANGING THE DEFAULT PARAMETERS

The software automatically carries out the measurement using default parameters (these will be displayed before the measurement is started. See also the technical specification, section 1).

If you want to change these parameters (normally, however, default parameters should always be used) choose the function "Run parameters" and press the Enter key. Two windows will appear: the left one containing the parameter names and the right one containing the present values for the parameters.

The default parameter values are :

Pulse counting time 1 s,
Number of observations 400 pcs (20 pcs in both X- and Y-directions),
Step length 3,5 mm in both X- and Y-directions.
Distance between formation determinations 70 mm.

As a default cross directional strip will be measured. If you want to measure sample sheets glued one after another choose the function 'Run parameters' in the main menu slide the light bar using the arrow down key to the point 'Sample : CROSS DIRECTIONAL STRIP' and press the Enter key to obtain the setting 'Sample : CONSECUTIVE SHEETS'.

Choose the desired parameter and press the Enter key to get the input prompt. The input values will be inspected and if found to override the preset limits the program gives a prompt to the screen.

The changed values for the parameters will be kept in memory in the hard disk file BFT.CFG until following change made by the operatore. Therefore check periodically that you are really using desired parameters for the measurement.

The absorption coefficient value will also be retained inthe BFT.CFG file. If you have temporarily changed the value of the absorption coefficient remember to give it the right value after the measurement.

FORMATION MEASUREMENT

After the sample spool with the sample has been properly set into the tester the measurement will be started by choosing the first row 'Start of measurement' in the main menu. Then the input window for sample parameters will appear. The software asks for the sample name, (weighed) grammage of the sample and the number of sheets (determinations) for the sample. Having given this information the software prompts for the same information for possible other samples.

There may be up to 20 sample groups each consisting of unlimited amount of measurements (Sheets). Check however, that it is possible to measure the number of determinations set from the sample length. The total possible amount of sheets per loading is 200 (this - of course - depends on the properties of the sheets).

As mentioned above in section 4 the grammage of the sheet is required for the modified indices of formation only (i.e. the normalized formation index and for the coefficient of variation) and thus any value between 1...300 g/m2 will do. **Then, of course, the values of the modified indices will be incorrect** (The index of formation, i.e. the std. deviation of grammage, will be correct always if only you have used the correct absorption coefficient of beta radiation, obtained through proper calibration).

Before the measurements starts you may still change your inputs by answering Yes to the question 'Would you like to change something?' (Y=Yes, N=No).

Having received all necessary data for the samples the software displays the measuring parameters giving the final possibility to alter something, checks the interconnection between the formation tester and the computer, moves the detector frame to the proper starting point and checks the interconnection to the matrix printer as well as to the scintillation counter detector.

If you have forgotten to switch the power on to some of the apparatus or if the printer has been set OFF LINE (you will easily forget it to OFF LINE when manually advancing the paper when taking out the printouts) the software will give a prompt to the user. <u>If the cable between the printer and the computer has not been properly connected the program cannot identify it and you will lose the printout.</u>

After everything has been properly set the software will start the measurement. The status of the measurement will be easily seen at the monitor screen.

For each determination a printout sheet will be outputted and after the sample set a summary of the results will be printed out.

HOW TO PAUSE THE MEASUREMENT

If you would like to pause the measurement for some reason it is possible by lifting up either of the sheet pressing rollers. The program prompts the user then and gives a possibility both for continuation and for termination of the measurement.

AT THE END OF THE MEASUREMENT

At the end of the measurement you may leave the power switched on to the tester. The tester has been designed for continuous operation. You can increase the life of the

monitor screen by decreasing the brightness to a proper level - not too high - because along with the time the image will be 'burned' to the fluorescent layer of the screen.

ZERO FLUX DETERMINATION

Zero flux is the amount of beta radiation entering the detector without any sample in the measuring gap (i.e. at the grammage level equal to zero). Zero flux value is a handy tool for monitoring the condition of the beta radiation source : along with the time the zero flux should slowly go down as the source gets weaker. The half life decay time of the source is about 2.5 years.

You may enter the zero flux determination procedure from the 'Main menu' by choosing the 'Additional features' and thereafter the 'Zero flux measurement'.

If the zero flux rapidly drops (within some days or so) it is an indication of some dirt possibly entered the collimator tube. The collimator should the be cleaned according to the procedure given in the section 7.

If the standard deviation of the zero flux determination is too high it is an indication of malfunction in the detector system : if the high voltage setting is incorrect for the detector used - too high or too low - the detector will get instable. The properties of the vacuum photomultiplier tube at the detector may change along with the time thus making it necessary to readjust the high voltage setting.

According to the theory the std. deviation of beta radiation is equal to

$$100\ \sqrt{n}\ /\ n$$

(per cent), in which n is the zero flux level.

To behave according to the theory the number of observations in the zero flux determination must be high enough.

6. CALIBRATION OF THE TESTER

6. CALIBRATION OF THE TESTER

At each point of the measurement the pulse counts (i.e. transmittances of beta radiation) are converted to corresponding grammage values using the following formula :

$$m_i = M - (1 / \mu) \cdot \log (n_i / N)$$

in which
m_i = a grammage value
M = (weighed) average grammage of the sheet
μ = absorption coefficient of beta radiation
n_i = a pulse count value
N = the mean of pulse counts

The numerical value of the absorption coefficient depends on the level of grammage M of the sheet. It is essential to use the right absorption coefficient value as it directly affects the numerical value of the formation index.

The correspondence between grammage and the absorption of beta radiation (i.e. the absorption coefficient) will be empirically determined as follows :

1) For the calibration a set of different machine made papers at different levels of grammage will be chosen in such a way that the grammage range adequately cover the range used, 20...300 g/m^2 (if the tester will be used e.g. within the range 20...100 g/m^2 the calibration within the range 20...150 g/m^2 will be sufficient. The sample sheet set delivered along with the tester may well be used for the calibration. It is a good practice to keep the calibration sample sheet set in a sheltered place and to perform always the calibration using the same sheets.

Adequate grammage levels for the calibration sheets could be e.g. 20, 30, 45, 60, 80, 100, 125, 150, 175, 200, 250 and 300 g/m^2. (The calibration sheet set supplied with the tester contains samples of different grades at basis weight levels 35, 46, 54, 63, 77, 88, 99, 108, 121, 128, 146, 159, 218, 226, 245 and 270 g/m^2). As the exact grammage of the sheets must be known for the calibration it should be measured (weighed) most precisely at the same climate, humidity and temperature, (i.e. in the same room) in which the actual formation measurement will be carried out. It is advantageous for the calibration if the formation of the sheets used for calibration is good (even) as the grammage of the measured area, 70 x 70 mm^2, will be as close as possible to the average weighed grammage of the sheet. In addition to the sheets also the zero pulse flux will be measured (zero pulse flux is the amount of beta radiation entering the detector

without the sample i.e. at the grammage level equal to zero).

2) According to normal practice (see operational instructions, formation measurement) the formation of the sheet (default parameters, 400 points) is to be measured.

For determination of the absorption coefficient the mean of the pulse counts (c/s) and the average (weighed) grammage will be taken from the printouts for each of the sheets.

The calibration curve may now be determined manually or according to a routine in the Formation Tester software as follows :

MANUAL OPERATION :

3) The obtained pairs of grammage and pulse count are to be drawn to a semi-logarithmig paper such that grammage lies on the linear scale and the pulse count lies on the vertical logarithmic scale (a millimeter paper may also be used but then instead of pulse count values the natural logarithms of the pulse count values are to be drawn onto the vertical scale). Using an adequated curved ruler a curve is to be drawn along via the points drawn such that the shape of the curve is as smooth as possible (does not contain kinks et.c.). According to the experience the curve is very linear within the range 20...100 g/m^2.

4) The absorption coefficient for each level of grammage may now be obtained through determination of the tangent (slope) at the point of the curve corresponding to the grammage desired. This may be done e.g. using the secant method :
Let'a assume the coefficient will be desired for grammage 60 g/m^2. Using the curve drawn the pulse flux at grammages 20 g/m^2 higher and lower than 60 g/m^2 will be taken (in this case 80g/m^2 and 40 g/m^2).

The slope of the tangent (i.e. the absorption coefficient of beta radiation may now be obtained using the formula

$$\mu = - \frac{\log (n_2 / n_1)}{M}$$

in which
- μ = absorption coefficient of beta radiation
- n_2 = pulse flux at the level grammage +20 g/m'
- n_1 = pulse flux at the level grammage -20 g/m'
- M = the (weighed) average grammage of the sheet.

IT IS EXTREMELY IMPORTANT TO PRECISELY DETERMINE (WEIGH) THE GRAMMAGE OF THE CALIBRATION SHEETS AS THE NUMERICAL VALUE OF THE ABSORPTION COEFFICIENT AND THEREBY ALSO THE NUMERICAL VALUE OF FORMATION INDEX DEPEND ON IT.

5) It is handy for the operator if after the calibration a table (or curve) is made in which the absorption coefficient is given as a function of grammage. The vertical axis (absorption coefficient) should be scaled such that it is possible to read the rumerical value of the coefficient with a precision of approximately five decimals (0.00000).

OPERATION WHEN USING THE CALIBRATION PROCEDURE WITHIN THE PROGRAM:

Automatic operation is easier and does not produce errors in the absorption coefficient if carried out properly according to the instructions given:

3) Start the calibration routine as follows: Choose 'Additional features' in the main menu.
Choose 'Calibration' in the features menu window by moving the selector bar to the right place with the up or down arrow keys and press Enter.

4) Give the number of calibration sheets measured (answer the questions as prompted) and fill the table that appears to the top left corner of the screen: in the left column type the grammage of the sheet (precision of 1 g/m² is enought, no decimals are required) and in the right column type the average pulse flux (read this from the tester printout for each sheets). As you have filled all the places in the table the program calculates the absorption coefficient (i.e. places a linear regression curve into the points) and also gives an estimate of the fit. If the fit is found to be inadequate the program prompts this to the user.

5) Press the space bar (or any key) to enter the next step. Here the program displays the calibration curve with the absorption coefficient. The measured points should lie neatly on the regression line. The program prompts you: "Do you accept the new value ?? (Y/N)". If you answer "Y" the program stores the new value as a default and returns to the main menu.

At the beginning the calibration of the tester should be checked at least once a month. Later on the calibration may be done with longer intervals (some users calibrate the tester once a year only with the calibration remaining constant). It is a good practice to keep the calibration sample sheet set in a sheltered place and to perform the calibration always using the same set.

It is also possible to monitor the stability of the calibration by plotting the pairs of grammage and the mean of pulse count to the calibration curve chart made (point 3 above). If the points systematically get further from the curve this indicates that a new calibration should be done.

This kind of a check is not valid if the grammage of the samples normally measured lies within a very limited range (e.g. 30...60 g/m²).

As the intensity of the source of radiation gradually decreases along with the time the calibration curve will move to a different height along with the time. This, however, does not necessarily affect the absorption coefficient if only the shape and the slope of the curve remain the same (i.e. if the vertical distance with the two curves is the same (in millimeters) at each point of the curves).

It is possible to compensate the decrease of the intensity to some extent by increasing the pulse counting time. The mean of the pulse counts (measured through the sheet) may be obtained by multiplication of the pulse count value (c/s) in the printout by the pulse counting time (s).

Along with the time dirt (loose fibres, filler, coating colour) may be accumulated into the collimator tube. This dirt will absorb some of the radiation, too and thus decrease the pulse flux (then the intensity of the source seems to go down more rapidly than normally). If this is suspected the collimator and the beta radiation source must be cleaned (see section 7).

7. REMOVAL AND INSTALLATION OF THE BETA RADIATION SOURCE

Handling of the beta radiation source
Removal and installation of the beta source
When to change the source
Cleaning of the collimator and the source
External radiation around the tester

7. REMOVAL AND INSTALLATION OF THE BETA RADIATION SOURCE

HANDLING OF THE BETA RADIATION SOURCE

In many countries (especially in Scandinavia) an official permission is required for the use of radioactive material. This permission is usually granted by the local Office or Institute for Radiation Safety. The permission names the person in charge of radioactime material and of the use of it within a company. The legislation on the handling of radioactive material may vary from country to country but to avoid possible problems arising, only the person in charge of the radioactive materials should handle the source (i.e. install, remove, clean as well as to properly discard or store the used 'dead' sources).In many countries a separate label with the text, visible enough: "CAUTION, RADIOACTIVE MATERIAL" is required to be placed near the tester.

It must be pointed out, that the source - despite of what has been said above - is quite harmless: it is rather weak in activity and it is also quite an ideal beta radiation source which means that it does not output gamma or alfa radiation. No special precautions neither radiation dosimeters are necessary for the handling of the source. Only follow carefully all of the instructions given below. As the human skin always contains acidous (corrosive) components we recommend that the source should be handled using suitable tweezers, or if not applicable, using thin rubber or plastic gloves.

DO NOT attempt to use any other kind of a radiation source than that recommended by AMBERTEC in the tester. The shielding has been designed for Pm-147 Beta point sources only. DO NOT damage or modify the collimator/detector assembly of the device.

In case of a fire it is recommended to remove the specimen scanner unit to a safe location - as all of the devices at the mill even containing small amounts of radioactive materials.

The following procedures should be carried out by operators with adequate knowledge and training in radiological safety only. See chapter 8. too.

REMOVAL AND INSTALLATION OF THE SOURCE

The source of beta radiation seats within the collimator above the lower beam of the detector frame. In order to reach the source the detector together with it's collar as well as the sheet pressing cup must first be removed (see section 8 of this manual).

After the detector and the sheet pressing cup have been removed the brass collimator with the polished surface may be seen. Remove the collimator by lifting it up; if it seats tightly in it's place screw it slightly right and left and lift it carefully up.

If necessary, remove the source holder screw from the collimator by turning it counterclockwise. While doing this hold the collimator upright (as it was in the detector frame) in order to prevent the tiny (2 mm in dia, length 10 mm) source from accidental dropping and disappearing.

The source, however, usually seats rather tightly in its place. It may be carefully pressed out from the holder using a steel wire (a needle will do well) through the small hole at the underside of the source holder. **DO NOT TOUCH OR SCRATCH THE TOPSIDE OF THE SOURCE (the radioactive material is at the top end of the source).** As already said above it is wise to handle the source using tweezers or thin rubber (plastic) gloves to prevent the corrosive grease from the fingertips from entering the surface of the source and to prevent fingers from eventual contamination if the active source disc should have been damaged.

The active end of the source may be cleaned from eventual dirt (dust) by blowing air using the bellows supplied along with the tester. See page 73. You will easily recognize the active end of the source: the active disc, 1.3 mm in diameter is placed in a small cavity drilled at the end of the source capsule.

Insert the source (by pressing it gently) to its hole in the source holder (the active disc end of the source must point out (up), of course) and - still holding the source holder upright - screw the source holder carefully inside the collimator. As you feel the holder to stop inside the collimator you must not try to screw it further to avoid damage to the threads. Fasten the locknut at the holder.

Install the collimator, sheet pressing cup and detector to it's place and fasten the two allen key screws of the detector collar.

WHEN TO CHANGE THE SOURCE

The half life decay time for Promethium is about 2.4 years. Within this time the intensity of the source will go down to a half of the original one. As the pulse counting time gets inconveniently long (to obtain a proper level of pulses through the sample) it is the time to replace the source by a new one:

The old source :

Remove the old source according to the procedure above and put it into the metal can in which it was delivered. It is a good practice to wear plastic or rubber gloves and to use tweezers in the handling of the source. Although the old sources are very weak (dead) they - according to the legislation of most countries - must be stored for possible later inspection by the local Institute for Radiation Safety. Most institutes also receive old sources (for storage or disposal treatment).

The new source:

Insert the new source (by pressing it gently) to its hole in the source holder. The active disc end of the source must point out (up), of course. You may recognize the active end from the tiny (1.3 mm in diameter) active (darker) disc at the bottom of a small cavity drilled at the end of the source rod. Save the metal can of the source for later use.

Holding the source holder upright screw the source holder carefully inside the collimator. As you feel the holder to stop inside the collimator you must not try to screw it further to avoid damage to the threads. Fasten the locknut.

Place the detector and the sheet pressing cup according to the instructions given above and fasten the detector with it's collar to the frame.

CLEANING OF THE COLLIMATOR AND THE SOURCE

If the zero flux decreases quite rapidly it usually signals operator that the collimator gets dirty. In some cases loose fibers or filler particles from the surface of the sample (e.g. laboratory handsheets) may enter the collimator tube. The dirt absorbs radiation and must therefore be cleaned out.

Clean the collimator according to the following procedure :

Procedure A.

Insert a piece of thin cardboard (size approximately 10 x 10 cm) into the measuring gap. Take the pumpette (bellows) delivered along with the tester and fit the nozzle at the end of the hose onto the small hole at the side of the collimator. Using the piece of board lift up the brass sheet pressing cup and squeeze the bellows a couple of times to force air to the collimator. The air then forces possible dirt up and out from the collimator tube. The piece of cardboard prevents dust from entering up into the sheet pressing cup through the measuring opening.

Check the zero flux. If no change in the zero flux reading was to be seen there might still be dirt in the collimator that requires more thorough cleaning according to the procedure below :

Procedure B.

Remove the detector (see section 8) and lift up the collimator.
Take a plastic bag, a piece of plastic hose about 0.9 mm in diameter (obtainable through AMBERTEC or could be obtained by removing the plastic insulation from a thin electric wire) and a cotton end stick (commonly used in the cosmetics) or a piece of swab. Keeping the collimator in upright position (i.e. as it is in the detector frame) remove the source holder screw from the collimator by turning it counterclockwise. It is wise to work above the

opened plastic bag: if you should drop the source it will not get lost but will be retained in the bag.

Hold the collimator above the opened plastic bag and clean the collimator tube by dropping the piece of the plastic hose through the collimator.

DO NOT ATTEMPT TO USE ANY METAL WIRE TO CLEAN THE COLLIMATOR AS THE SOFT BRASS COLLIMATOR SURFACE WILL EASILY BE DAMAGED. This will decrease the precision of the measurement.

Very gently wipe the surface of the beta source clean from eventual dirt using the cotton end stick (or swab) and put the stick also into the plastic bag. **THERE IS A VERY THIN METAL WINDOW ON TOP OF THE SOURCE, MADE OF PALLADIUM AND OF SILVER TO PREVENT ANY CONTAMINATION. DO NOT SCRATCH THE SOURCE SURFACE TO PREVENT ANY DAMAGES TO THE SOURCE. USE NO HARD MATERIAL (METAL, PLASTIC, WOOD) FOR CLEANING!**

Close the plastic bag and store it for inspection before disposal. Screw the source holder clockwise into the collimator, fasten the locknut, install back to the detector frame, check the zero flux level and fasten the detector.

EXTERNAL RADIATION AROUND THE TESTER

The tester has been tested by the Finnish and Swedish governmental offices for radiation safety. Under normal use no external radiation was observed even when using 8 mCi sources that were available at that time. At the moment the highest activity available through Amersham is 3 mCi in this kind of a point source.

According to measurements carried out by the Swedish governmental office for radiation safety (SSI) following levels of radiation were observed. Please note that in the test the tester was loaded with a 5 mCi Pm-147 source as the sources obtainable today are of 3 mCi only :

Assembled (i.e. ready for operation) device, measured as close to the beta source as possible, at the sheet pressing cup, at the height of the measuring gap:

- less than 2 µSv/h with paper in the measuring gap, i.e. with closed gap,
- 17 µSv/h with totally open (2 mm), empty gap

Assembled device, measured at the gap height, at a distance of 10 cm from the source:

- less than 2 µSv/h with totally open

(2 mm), empty gap.

The above exposure rates are negligible under normal operation of the tester. Thus the user will not be exposed to radiation and no personal radiation dosimeter will be necessary.

As the collimator (loaded with the source) is removed from the detector frame a rate of 600 µSv/s was observed at the collimator tube opening.

The source, removed from the collimator gave a rate of 125 mSv/s.

µSv/h = microsievert per hour
µSv/s = microsievert per second
1 µSv/h equals to 0.1 mrem/h (mR/h)

The measurements were carried out by SSI, Sweden, (the Swedish governmental office for radiation safety) using a Philips ZP 1430 GM tube with brass lens (made by SSI) and a Bicron type Labtech scaler ratemeter.

8. REMOVAL AND INSTALLATION OF THE DETECTOR

8. REMOVAL AND INSTALLATION OF THE DETECTOR

The following procedures should be carried out by operators with adequate knowledge and training in radiological safety only. See chapter 7. too.

Handle the scintillation counter detector carefully. There is a vacuum photomultiplier tube inside the detector casing and rough handling of the detector may cause dislocation of the multiplier dynodes inside the tube.

Remove the detector as follows :

1. Adjust the high voltage to zero using the high voltage setting potentiometer at the front panel of the control unit box. Remove the high voltage cable from the control unit.

2. Remove the two Allen key screws fastening the detector collar to the detector frame (key delivered in the tool set). Do not touch the three small locking screws that lock the detector to a right level in the detector collar.

3. Take a firm grip to the detector collar with your right hand and support the sheet pressing cup at the lower end of the detector to prevent the cup from dropping down. Gently lift the detector upwards. The detector fits quite tightly to the detector frame; it may be necessary to rotate the collar with the detector slightly when lifting up. When lifting, remember to support the brass sheet pressing cup with your left hand finger all the time. The cup must not be dropped because it will easily be deformed and when deformed it may jam to the detector collar when the sample movement may be disturbed (the sample either jams or will not be pressed against the collimator - both cases causing incorrect results).

   NOTE THAT THE COLLIMATOR HOLE OUTPUTS BETA RADIATION ALL THE TIME !! DO NOT UNNECESSARILY EXPOSE YOUR BODY (fingers or especially eyes) TO THE RADIATION ! It is worth to notice, however, that the transmittance of the outputting radiation is relatively low: it does not pass through a board sheet of 350 g/m² and it will easily be stopped by clothing or the utmost layers of the human skin.

4. Now you may remove the sheet pressing cup and carefully lay the detector sideways to a level surface. Do not dismantle the collar from the detector neither the shelter ring at the lower end of the detector tube. Behind the shelter there is a thin opague sheet and the scintillation plastics sheet. If you remove these and expose the tube to a strong light (ordinary room lighting will be enough) the tube may be damaged.

Install the detector tube as follows :

5. Install the detector tube carefully to the detector frame

by supporting the sheet pressing cup at the lower end of the detector. Fasten the two Allen key screws but not too tightly to prevent any damages to the aluminium threads at the detector frame.

6. Fasten the high voltage cable to the control unit and adjust the high voltage using the high voltage setting potentiometer. If the high voltage cable has been removed from the detector fasten the cable to the detector casing using plastic bandage or electric insulation tape.

REMOVAL AND INSTALLATION OF THE DETECTOR INTO THE COLLAR

If it will be necessary to remove the detector from it's collar unscrew the three Allen key locking screws until you can slide the detector out (upwards) from the collar.

When reinstalling, take care not to damage the collar, the detector tube or the sheet pressing cup.

Before you tighten the detector locking screws gently insert a 2.0 mm thick gauge (the surface and edges of the gauge MUST be scratchless) into the gap between the collimator and the sheet pressing cup. **Take care not to damage the polished surfaces of the collimator and the sheet pressing cup!!**

Slide carefully the detector downwards until you feel it to touch the bottom of the sheet pressing cup. Tighten the three locking screws - not too tight however, to prevent damages to the detector.

APPENDIX G : SAMPLE OF THE DOCUMENTATION ACCOMPANYING THE DEVICE

AMBERTEC Beta Formation Tester

OPERATION MANUAL Ser.nr.

AMBERTEC Beta Formation Tester

OPERATION AND MAINTENANCE MANUAL

1. TECHNICAL SPECIFICATION

1. TECHNICAL SPECIFICATION

Measuring principle :	Transmittance of beta radiation
Speed of measurement :	The routine measurement (consisting of 400 measured points, pulse counting time of 1 second) takes less than 14 minutes using the computer according to specifications below.
Measuring aperture :	1 mm
Movement of specimen :	Stepwise scanning. During pulse counting the specimen is stationary.
Distance between adjacent points :	3,5 mm (default) in X- and in Y-directions. The distance is separately adjustable in both directions.
Number of measured points :	400 kpl (default), adjustable between 2...9999
X-direction	20 pcs (default), adjustable
Y-direction	20 pcs (default), adjustable
	The measuring program gives the dimensions of the area to be measured.
Pulse counting time :	1 s (default) per point. Adjustable between 0,1...20 s.
Width of sample sheet :	Max. 210 mm (A4 format width).
Length of sample sheet :	Unlimited.
Grammage range :	20...300 g/m². At grammage levels below 30 g/m² a light pressure cup is to be used (obtainable through AMBERTEC).
Width of measured area :	about 70 mm (length of measured area depends on the length of the sheet)
Source of beta-radiation :	Promethium-147, NO OTHER NUCLEAR ISOTOPE MUST BE USED. Sealed type source, nominal activity 3 mCi, type Amersham PHCK 3556 (type code might vary according to the supplier) capsule type X110. The distance between the source and the detector is adjustable.
	In the use of the tester the local legislation for radiation safety is to be followed. In Scandinavia a permission for use, given by the local Institute for Radiation Safety

is required. The permission names the local person in charge of radiation safety.

The source of radiation seats shielded in the tester and there will be no radiation leaking outside the measuring gap. Thus the user will not be exposed to radiation and no personal radiation dosimeter will be necessary.

Collimator : Brass, Diameter of the collimator tube 1 mm, length of the collimator 2.5 mm

Detector of radiation : Scintillation counter detector Type, Nuclear Enterprises DM1-1, Scintillator : NE810, Plastic

Measuring gap : The distance between the beta-source and the detector is less than 10 mm. A brass sheet pressing cup (around the end of the detector) presses the specimen tightly against the collimator thus preventing the movement of the specimen up and down in the gap. The distance between the collimator and the sheet pressing cup (i.e. the measuring gap) is adjusted to 2 mm.

Scanner mechanism : The sample to be measured is rolled around the sample spool or is fed to the tester one sheet at a time. The movements are performed using stepper motors. The detector and the source of radiation are fixed to a scanning detector frame (X-direction). The specimen is moved through the tester by nip traction.

Computers : The movements and the pulse counting is controlled by a CPU card which is connected to the main controller via an RS-232 serial interface.

The main controller is an IBM-PC/AT -compatible computer fulfilling following requirements:

640 kB RAM, clock frequency 10 MHz, floppy disc drive reading at least 360 kB format, hard disc, Centronics-port (for printer), 2 pcs RS-232 serial ports, keyboard, monochromatic (Hercules) or EGA display, MS-DOS 3.3.

The measuring program prints out in colour (matrix printer STAR LC-10 Color and compatibles).

The programs :

The programs are stored on a 360 kB format floppy disc from which they can be installed (copied) to the hard disc. Programs are not copy protected but the user company name will be printed to the printouts.

It is the policy of AMBERTEC to supply the new version to all AMBERTEC Beta Formation Tester owners whenever the program has been updated. This gives the benefits of developments to all users and minimizes the versions of programs around. For this reason no mnemonic source code of the programs will be supplied.

AC-connection :

Three (3) connections with protective grounding (Schuko) 220 V :
one for AMBERTEC Beta Formation Tester (220 V ± 10 %, 50 Hz),
one for the computer and one for the matrix printer.

If there are strong variations (transients) in the AC supply network a static regulator or an uninterruptible power supply (UPS) is recommended.

The AMBERTEC Beta Formation Tester has been designed for continuous operation. The device has been protected by electrical fuses (3 pcs: 2 in the controller box and 1 in the controller computer).

Operational conditions:

The tester is aimed for use in ordinary laboratory rooms. However, the tester should not be exposed to severe vibrations (sometimes present at paper mill laboratories) as the detector dynodes (in a vacuum photomultiplier tube) might be damaged.

As paper is very hygroscopic possible variations in the humidity of the ambient atmosphere will affect the grammage variation of the sheet thus affecting also the formation index. Therefore it is recommended to use the tester in laboratories incorporating proper air conditioning for constant climate.

Measures:

Soecimen scanner : (width x height x depth) 45 x 17 x 27 cm

Control unit box : 35 x 20 x 45 cm

Computer :
Keyboard :
Monitor screen :
Matrix printer :

Space requirements :

Specimen scanner should be placed at the table in such a way that the operator may stand on the right side of the scanner.

To minimize the table size the tester may be installed such that the specimen scanner, monitor screen, keyboard and printer are at the table and the computer and the control unit are placed on shelves under the table (necessary ventilation for computer to be provided). The tester then requires table area of about 120 x 60 cm.

If all modules of the tester will be placed on the table the tester requires about 200 x 60 cm of table area.

No restricted area reservations (due to the radioactive source) are necessary.

2. CONTROLS AND CONNECTORS

CONVERSATION RECORD

TIME 1130 | DATE 3-14-90

TYPE: ☐ VISIT ☐ CONFERENCE ☒ TELEPHONE ☐ INCOMING ☒ OUTGOING

Location of Visit/Conference:

NAME OF PERSON(S) CONTACTED OR IN CONTACT WITH YOU	ORGANIZATION (Office, dept., bureau, etc.)	TELEPHONE NO.
M. R Collmes	MK Systems	508 774-1810

ROUTING

NAME/SYMBOL	INT

SUBJECT: N.L.

SUMMARY

Mr Collmes called after receiving deficiency letter. He asked if they needed to address all the items in the letter. I told him that he must address each item and answer as specifically as possible. He further stated that he would reconsider obtaining a license since this was all a big pain. Emphasized that it was his decision and to send us a letter either way.

ACTION REQUIRED

None

NAME OF PERSON DOCUMENTING CONVERSATION	SIGNATURE	DATE
C Eckert	C Eckert	3-14-90

ACTION TAKEN

SIGNATURE	TITLE	DATE

MAR 05 1990

Docket No. 030-31314
Control No. 111643

M/K Systems, Inc.
ATTN: Otto J. Kallmes
President
12 Garden Street
Danvers, Massachusetts 01923

Gentlemen:

This is in reference to your request for a byproduct material license. In order to continue our review, we need the following additional information:

1. In Item 5. of your application you request authorization for promethium-147 with a maximum activity of 12 millicuries (mCi). However, you do not indicate in what form the radioactive material will be, what the maximum activity per source will be, or the exact model number of the source.

   Please provide the above information.

2. In Item 6. of your application you state that the source will be an integral part of a Beta Formation Tester. The information provided does not indicate specifically what the gauge will be used for.

   Please provide the above information.

3. In your application there is no indication as to exactly what type of service your company will be providing. There must be an explanation stating specifically the activities you are requesting authorization for. For example, will you be a gauge distributor, service facility, installer and/or training provider?

   Please provide the above information.

4. In Item 7. of your application you state that you have received training in the use of the equipment which employs the promethium-147 source. Further, you indicate that the training was provided by Mr. Antero Komppa from the manufacturing company. There is no information provided as to when the training took place, how long it lasted or the topics covered. Also, there is no indication of Mr. Komppa's qualifications to perform such technical training. Furthermore, in Item 7 there is no indication

that you have received training in basic radiation safety which includes the following topics:

a. The principles and fundamentals of radiation protection and good safety practices related to the use of radioactive materials.

b. Radioactivity measurements, use of radiation detection instruments and monitoring techniques.

c. Biological effects of radiation.

d. Procedures for performing the services requested.

e. Actual practice in performing the services.

The information described above must be addressed for each individual you request to be listed, as an authorized user, on your license. The name of each individual must be indicated.

Please provide the above information in the form of course outlines, resumes and other such relevant material.

5. In Item 8. of your application, you state that no other employees will be involved with the gauge. However, Item 10 states that a total of six employees will be presented with a brief description of the use, care and precautions regarding the gauge, at least twice a year. It is necessary to distinguish who will be installing, handling and servicing the gauge and source and which employees, if any, will be providing training on the use of the gauge and the installation of sources. Employees not listed as authorized users who will be working under the direct supervision and in the actual presence of an authorized user must receive training not only on gauge operation but also on radiation safety. This training must be given by a qualified individual. The training must be provided prior to the use and handling of the gauge/source and at least annually thereafter.

Please submit the above information which should include resumes, outlines and other such relevant information or statements.

6. In Item 9 of your application, you state that the gauge will be located on a bench in your electronics shop. A diagram of your facility, which includes the specific locations of gauge use, servicing and storage and an indication of the surrounding rooms and areas, was not included.

Please provide the above information.

7. In Item 11 of your application, you state that a depleted source will be returned to the supplier (Amersham International) after a period of two years. The application does not indicate whether your company will be obtaining new sources, installing them and then returning the old sources or whether you are leaving any one or all of these tasks to the purchaser. Procedures for ordering, receipt, installation, safe handling of radioactive materials and return of sources to the supplier are needed. If any of these activities will be conducted by the purchaser, you must submit the model procedures you will be recommending each purchaser follow.

   Please provide the above information.

8. In your license application, you do not address the requirement for leak testing of sealed sources and the interval at which the testing will occur. Please provide the following information:

   a. The exact procedures for leak testing each source.

   b. The time interval at which testing will occur.

   c. Who will perform the leak testing; if performed by an NRC or Agreement State licensed facility, provide the name and license number. If provided by any other facility, provide a copy of their leak test procedures. If performed by yourself or the purchaser submit the exact procedures to be followed including the counting of the leak test sample and the qualifications of the individual performing the procedure.

   Please submit the above information.

9. In your application, you do not indicate what procedures will be followed by your staff in the event of a damaged or leaking source. The procedures should include, but not necessarily be limited to, actions to prevent contamination and who will be notified in case of an emergency.

   Please submit the above information.

10. In your application, you do not specify if you possess any radiation detection instruments which are available at your facility. Please provide the name of the manufacturer, the model number of the instrument and probe appropriate for the type of radiation in question. You must also describe the procedures for calibrating the instrument. If this will be done by another company, provide their NRC or Agreement State license number or a copy of their calibration procedures.

    Please provide the above information.

11. In your application, there is no indication that personnel monitoring devices will be provided to your employees. Companies engaged in the servicing, installation, relocation or shipping of source containing gauges must provide extremity monitoring devices to all employee's engaged in licensed activities.

    Please confirm that extremity monitoring will be provided.

12. In your application, you do not indicate that all servicing will be conducted in accordance with the manufacturer's specifications and instructions.

    Please confirm.

13. In your application, there is no reference to the type of training you will provide to each individual who purchases a gauge. This training should include, but is not limited to, operation, safe source handling, care and maintenance and radiation safety. Procedures for the cleaning of the collimator opening should be outlined.

    Please submit the above information.

We will continue our review upon receipt of this information. Please reply in duplicate to my attention at the Region I office and refer to Mail Control No. 111643.

If we do not receive a reply from you within 30 calendar days from the date of this letter, we shall assume that you do not wish to pursue your application.

Sincerely,

Original Signed By:
John D. Kinneman

John D. Kinneman, Chief
Nuclear Materials Safety Section B
Division of Radiation Safety
and Safeguards

Enclosures:
1. 10 CFR Parts 19, 20, 30 and 32
2. Regulatory Guides 404-4
3. Form NRC-3

RI:DRSS
Eckert/cs/pmb
02/12/90

RI:DRSS
Kinneman
02/14/90

OFFICIAL RECORD COPY ML 111 ECKERT - 0003.0.0
02/06/90

CONVERSATION RECORD

TIME: 10 00 Am

DATE: 12-11-89

TYPE: ☐ VISIT ☐ CONFERENCE ☒ TELEPHONE ☐ INCOMING ☐ OUTGOING

Location of Visit/Conference:

NAME OF PERSON(S) CONTACTED OR IN CONTACT WITH YOU	ORGANIZATION (Office, dept., bureau, etc.)	TELEPHONE NO.
Mr Otto Kallmes	M/K Systems	508 774-1880

ROUTING

NAME/SYMBOL	INT

SUBJECT: License Application.

SUMMARY: Called Mr Kallmes to clarify answers to points in application.

① What type of use?
② # of users?
③ possession limit?

Mr Kallmes responded as follows:

① They want to distribute gauges, do in house testing, trade shows, installation and instruction on use, some minor circuitry repair but not sensor repair.

② There would be 3 people involved in handling the gauges. They have no training other than what he will instruct on to gauge operation

③ They will have approximately 3 units on hand ~~and~~ with 3 mCi per source so need 12 mCi.

ACTION REQUIRED: Follow up with clarifying letter after discussions with J. Kmiecik.

NAME OF PERSON DOCUMENTING CONVERSATION	SIGNATURE	DATE
C. ECKERT	C Eckert	12-11-89

ACTION TAKEN

OFFICIAL RECORD COPY

SIGNATURE	TITLE	DATE

ML 10

50271-101 ★U.S. G.P.O. 1983-381-526/8346 CONVERSATION RECORD OPTIONAL FORM 271 (12-76) DEPARTMENT OF DEFENSE

L&L 28458

NRC FORM 313
(10-87)
10 CFR 30, 32, 33, 34, 35 and 40

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED BY OMB
3150-0120
Expires: 6-30-90

APPLICATION FOR MATERIAL LICENSE

030-31414

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

Program Code: 03122

APPLICATIONS FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

U.S. NUCLEAR REGULATORY COMMISSION
DIVISION OF FUEL CYCLE AND MATERIAL SAFETY, NMSS
WASHINGTON, DC 20555

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS. IF YOU ARE LOCATED IN:

CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION I
NUCLEAR MATERIALS SAFETY SECTION B
475 ALLENDALE ROAD
KING OF PRUSSIA, PA 19406

ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION II
NUCEAR MATERIALS SAFETY SECTION
101 MARIETTA STREET, SUITE 2900
ATLANTA, GA 30323

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION III
MATERIALS LICENSING SECTION
799 ROOSEVELT ROAD
GLEN ELLYN, IL 60137

ARKANSAS, COLORADO, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TEXAS, UTAH, OR WYOMING, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
MATERIAL RADIATION PROTECTION SECTION
611 RYAN PLAZA DRIVE, SUITE 1000
ARLINGTON, TX 76011

ALASKA, ARIZONA, CALIFORNIA, HAWAII, NEVADA, OREGON, WASHINGTON, AND U.S. TERRITORIES AND POSSESSIONS IN THE PACIFIC, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION V
NUCLEAR MATERIALS SAFETY SECTION
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CA 94596

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S. NUCLEAR REGULATORY COMMISSION JURISDICTION.

1. THIS IS AN APPLICATION FOR *(Check appropriate item)*

- [X] A. NEW LICENSE
- [ ] B. AMENDMENT TO LICENSE NUMBER _____
- [ ] C. RENEWAL OF LICENSE NUMBER _____

2. NAME AND MAILING ADDRESS OF APPLICANT *(Include Zip Code)*

OTTO J. KALLMES
M/K SYSTEMS, INC.
12 GARDEN STREET
DANVERS, MA 01923

3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED.

SAME

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION

OTTO J. KALLMES

TELEPHONE NUMBER: (508)774-1880

SUBMIT ITEMS 5 THROUGH 11 ON 8½ x 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL
a. Element and mass number, b. chemical and/or physical form, and c. maximum amount which will be possessed at any one time.

6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED.

7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE.

8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS.

9. FACILITIES AND EQUIPMENT.

10. RADIATION SAFETY PROGRAM.

11. WASTE MANAGEMENT.

12. LICENSEE FEES *(See 10 CFR 170 and Section 170.31)*

FEE CATEGORY: 3P

AMOUNT ENCLOSED: $230.00

13. CERTIFICATION. *(Must be completed by applicant)* THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT, NAMED IN ITEM 2, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 20, 32, 33, 34, 35, AND 40 AND THAT ALL INFORMATION CONTAINED HEREIN, IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

WARNING: 18 U.S.C. SECTION 1001 ACT OF JUNE 25, 1948, 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

SIGNATURE–CERTIFYING OFFICER	TYPED/PRINTED NAME	TITLE	DATE
Otto J Kallmes	OTTO J. KALLMES	PRESIDENT	10/30/89

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	COMMENTS	APPROVED BY
App	Dec-5-I	3P		M. Knapp
AMOUNT RECEIVED	**CHECK NUMBER**			**DATE**
$230	16662			1/10/85

OFFICIAL RECORD COPY MLTA

NOV 20 1989 111643

5. Promethium 147, Maximum Activity 12 mi.

6. The source is an integral part of the Beta Formation Tester, and will never be removed from it except for replacement.

7. Otto Kallmes has been trained in the use of the equipment employing this source, the Beta Formation Tester, by Mr. Antero Komppa, the founder of Ambertec OY, the Finish company manufacturing it. Dr. Kallmes is a graduate chemical engineer (Northeastern University 1954) and has a PhD from the Institue of Paper Chemistry in Appleton, Wisconsin.

8. No other employees of M/K Systems, Inc. will be involved with the Tester.

9. The Tester will be located on a bench in our electronics shop for testing.

10. We have a total of six employees, and I will present a brief description of the equipment, its use, care, and precautions at least twice a year.

11. The source will be returned to the supplier, Amersham International after two years for replacement by a new one.

MB-10
11-30-89

BETWEEN:

LICENSE FEE MANAGEMENT BRANCH, ARM
AND
REGIONAL LICENSING SECTIONS

(FOR LFMS USE)
INFORMATION FROM LTS

PROGRAM CODE: 03122
STATUS CODE: 3
FEE CATEGORY: ----------
EXP. DATE: 0
FEE COMMENTS: ----------

LICENSE FEE TRANSMITTAL

A. REGION 1

1. APPLICATION ATTACHED
APPLICANT/LICENSEE: M/K SYSTEMS, INC.
RECEIVED DATE: 891120
DOCKET NO: 3031414
CONTROL NO.: 111643
LICENSE NO.:
ACTION TYPE: NEW LICENSEE

2. FEE ATTACHED
AMOUNT: $230.00
CHECK NO.: 16662

3. COMMENTS

SIGNED egmld
DATE 11:30:89

B. LICENSE FEE MANAGEMENT BRANCH (CHECK WHEN MILESTONE 03 IS ENTERED 11/1)

1. FEE CATEGORY AND AMOUNT: 3P $230

2. CORRECT FEE PAID. APPLICATION MAY BE PROCESSED FOR:
AMENDMENT ----------
RENEWAL ----------
LICENSE ----------

3. OTHER ----------

SIGNED S. Kimberly
DATE 12/5/89

VOID SHEET

Dec. 5 I
3P
111643

TO: License Fee Management Branch

FROM: Region I

SUBJECT: VOIDED APPLICATION

Control Number: 111643

Applicant: M/K Systems, Inc.

Date Voided: 90-05-02

Reason for Void: Applicant withdrew their request for a new license in letter dated April 17, 1990. Withdrawn after review.

Rebecca J. Brown 5/28/90
Signature Date

Attachment:
Official Record Copy of
Voided Action

FOR LFMB USE ONLY

Final Review of VOID Completed:

Refund Authorized and processed

No Refund Due

Fee Exempt or Fee Not Required

Comments:

Log completed 6/29/90
Processed by: JK

OFFICIAL RECORD COPY ML18