Accelerator Reliability Workshop
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Management of the reliability of medical accelerators

Information reported from different centres

Topics	Conventional Radiotherapy Reported from L. Bély –IGR -Villejuif J-Y Kristner – I. Curie-Paris	Neutrontherapy CERI/CNRS Orléans J. Briaud	Protontherapy CPO Orsay S. Meyroneinc
Kind of machine	Industrial machines - sold by big industrials - recent technologies - CE certification	Specific machines which have been designed for the nuclear physics research	
Main characteristics	Linac Photons: 18-25 MV Electrons : 6 -24 MeV	Cyclotron Neutrons (from neutrons): 50 MeV	Synchro-cyclotron Protons: 200 MeV
1- preventive actions			
Preventive maintenance: based on what criteria ?	- following the constructor recommendations - adapted considering the last events and the time allocated	We change the most failing element first	Consumable (water filtering, oil of vacuum pumps,…) , predictable wearing (bearings, filament…) basic checking (screw electrotechnical devices), administrative regulation (electricity, radiation protection calibration…)
Over-designed engineering/redundancy of equipment: compromise between price and safety margin	The design is completely assumed by the selling companies considering: - more than 25 years of experience - regulations and standards of commercial medical products The price of the overall maintenance is discussed during the call for bid. In some cases constructor sell a minimum rate of availability (difficult to evaluate)	Equipment built with fast connect module Redundancy of module Large safety margin	- historic over design due to self conception of the machine as a long-term research facility

	The choice between magnetron or klystron, or triod and diod, is a compromise investment cost / reliability and maintenance cost		
Extra-equipment (ex: Diesel)			UPS of 30 KVA: for quality and safety of powering of some devices
Tools for preventive maintenance: radiogammagraphies, monitoring on line, etc ..	Monitoring of some HF signal during the preventive operations General reporting from the users	Thermography for high power devices	Monitoring of 20 000 variables through the PLC and supervisor system (margins on flows, temperatures, general parameters, …)
2. When the failure is there			
Diagnostic tools: fast beam loss dataloggers, a posteriori analysis (archiving databases)		Comparison between data log during normal operation and Data on failure	Monitoring of 20 000 variables through the PLC and supervisor system (margins on flows, temperatures, general parameters, archiving of somes)
Failure archiving: electronic: electronic logbooks, excel, commercial software	Home-made electronic database archiving all the failures and repairing actions		Handwritten logbook Home-made database will be introduced (SQL) in the beginning of 2002
Spare part policy	The present tendency is the “shared” maintenance, that means constructors incite the customers to get a full stock of spare parts in order to fix quickly the failures.		For the major unspecific parts we have a spare part For some big parts (big power supplies) because of financial limitation we don’t have spare parts For some very specific part of the machine (rotative condensor, electronic of the ion source, …), because of lack of information of the design or too much experimental time needed to build and adapt a new one, we don’t have spare part
Operator’s training	Operators are trained and “certified” by the constructors in order to achieve level 1 and 2 of the maintenance		Each person of the technical staff receives a home-training on the machine (how to drive, how it is

	operations. "80%" of the failures are fixed by hospital technicians.		designed, how to fix level 1) There is no full dedicated operator of the machine. Each person of the technical staff (10 persons) is in charge of the machine operating one week each two months.
Standby on-call policy, cross training	Constructor has developed the "hot line" link in order to help hospital technician		During the night and the week-end two operators are informed through ALPHAPAGE + MINITEL ways of the eventual alarms on the machine (vacuums, magnets supplies, …)
3. after the failure			
When is it important to consider a failure as a serious problem to be solved ?	- not really serious (less than 2 hours) shifting the medical planning -serious, if the failure last more : shift the medical planning to Saturday - very serious, if more: reprogram patient on another machine	When the problem is recurrent or when the problem can cause important damage	- if it's impossible to get any beam able to treat - if it needs a long time to be fixed (spare part to build or to command, …), basically more than 2 days
Is it possible to predict failures (Weibull distributions) ?	With the analysis of the data recorded during the preventive maintenance	Sometimes with a good maintenance	Our own tool is the monitoring of the "normal" values (temperature, current, beam extracted, …) Example of prediction: over-temperature on one magnet then decision to clean the pipes during the following evening and night
Should this trigger preventive actions ?	Yes		In some cases, yes, to avoid long breakdowns
- Do you use troubleshooting software or procedures to find and shorten the failures when they happen ?			No
4. Organization			
- What kind of Research and Development	A lot of time is spent during the call for bid in order to evaluate the new		Nothing

projects are there in your Institutes which are related to equipment reliability ?	technology (other users, technical choices) and to negotiate the maintenance contract		
- What technical/organisational problems prevent you from having your 'dream' Machine ?		1- time 2- money	- time to operate on the machine -for some specific parts: time to experiment in order to prepare spare parts (rotative condensor) - the machine is more or less unique, no "scale effect" (no general upgrade of some parts) - budget - less sensitivity of the power supplies to the electrical network fluctuations
- Have you analysed the impact of Operators' training vs Machine downtime ?	In some cases, operator doesn't report troubles or little failures in order to avoid a technical operation (loss of time). A very good reporting from users is absolutely necessary	Yes and no but an old operator as a better reactivity on a failure , his experience is the better tool	In case of breakdown, we know that if the specialist of the concerned system is not there the breakdown is longer to fix. Thus, we try for each system to have two people with all the information
- Have you already made cost comparisons between preventive maintenance and curative maintenance in your Institute.	This is looked carefully before each new order	No but we are for preventive maintenance	No But the general law of this "old lady" it's that if we stop the renovation the long-term reliability will decrease
- Do you carefully study beforehand each piece of material which will be installed on an accelerator (properties under irradiation, lifetime)		We are careful with the neutrons effect	For the radiations: we try to put in a safe region (ex: optical encoder killed near the beam)- we have started discussion with COGEMA in order to get one of their hardened encoders For the magnetic field: some flowmeters don't work properly
5. the specific medical			

application			
- Specific ways to manage reliability due to medical application	- if possible degraded mode in order to end the day session of treatment -after each significant operation on the machine, a quality control of the beam is asked to medical physicist	In case of failure the downtime must be short Redundancy is the best way	- optimise more the doubling of systems or the spare-parts policy than the predictive approach (fixed quickly) - in case of problem, try to get beam to end the treatments of the day or of the week, in order to fix the problem during the evening or the week-end - during the breakdowns: permanent information with the medical staff in order to inform the patients, shift the treatment or delay it of one day - after each significant operation on the machine, a quality control of the beam is asked to medical physicist
Main “stories” of the last ten years: problems/solutions		Water leak on a dee inside the cyclotron Copper welding	- leaks on the septum of the electromagnetic channel (rebuild 2 spare parts with an industrial) - breakdowns a specific electronic board of the HF system (1^{st}: fix it, 2^{nd}: re-design a new board with an industrial) - water leak inside the chamber - internal short-circuit in a big magnet (solution in process) - breakdown on a quadrupole circuit
Recurrent troubles	General good behaviour of the accelerating parts. Some critical elements: vacuum, tubes More troubles on the new accessories: Multileaf collimator, portal imaging and … general software	Ion source ,water leak, vacuum leak	- general sensitivity of the big power supplies towards the electrical network fluctuations - tripping of the electronics controlling of the ion source