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DESIGN FOR REMOTE HANDLING IN THE SNQ TARGET STATION

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Abstract:

Due to the high radiation exposure the majority of components operated in the SNQ neutron target facility requires remote techniques when being handled for inspection and maintenance and also for replacement. Therefore the technical design of these components has to consider the suitability for remote handling and adequate handling procedures must be planned very carefully. Since the target (uranium) is the most radioactive component which also experiences the highes stresses during beam operation the planned design permits to directly move it mounted on a movable plug into a hot cell which is arranged immediately adjacent to the target block. A short description of the shielding plug and the target cell arrangement and equipment is given.

Furthermore some informations on facilities and procedures necessary for the safe handling of the essential target block components are reported.

1. Introduction

For all components of the SNQ plant which are exposed to high radiation or to thermo-mechanical stresses during operation, inspection and maintenance work at scheduled intervals and also repair or complete replacement of defective components must be planned very carefully in detail. In the neutron target facility effective and above all safe handling procedures are essential, primarily for the target.

The initial (/1/, /2/) design already envisaged that the target should be moved directly into a hot cell in order to be able to use proven standard hot cell equipment for handling. Optimization studies led to the arrangement of the target cell immediately adjacent to the target block below the experiment floor (-8 m) in a forward direction relative to the proton beam and to the design of a movable shielding plug on which the rotating target and other components (KLA-unit, H_2O-moderator) are mounted. This shielding plug slides on a track inclined at an angle of 45° between two positions: operating position (in the centre of the target block) and handling position (in the target cell).

Compared with previous designs (horizontally /1/,/2/ or inclined /3/ - also at 45°, but in a backward direction - connected to the target block) the arrangement now under investigation has the following 4 advantages:

- The proton beam area close to the target block can be designed much narrower giving more usable space for the experiments in the target hall and in addition enabling the installation of two more horizontal beam tubes (10 instead of 8 beam tubes for the H_2O-moderator).

- The end plate of the target shielding plug with its sealing and locking devices and the connection elements as well as the surrounding area will not be activated by neutron radiation, thus allowing the access of personnel to the end plate in case of failure of the remotely operated elements.

- A complete separation of handling of the target and the other components on the shielding plug from handling of the installations in the proton beam area (bending magnets, focussing elements).

- Special supply installations for the proton beam can be located underneath the proton beam tunnel (admittance) in the last 10 to 15 m in front of the target block.

Safe handling must also be provided for several components of the target block of the neutron target facility since stress during operation will probably limit their life. These components (see Fig. 1) are basically the reflector of the cold source, the cold source itself, shutters of beam tubes and neutron guides, choppers, special irradiation devices in the reflector of the cold source and the focussing magnets in the target block. The design for the handling of these components employs a separate handling system comprising a shielded container equipped with a hoist or manipulator and a movable shielding gate.

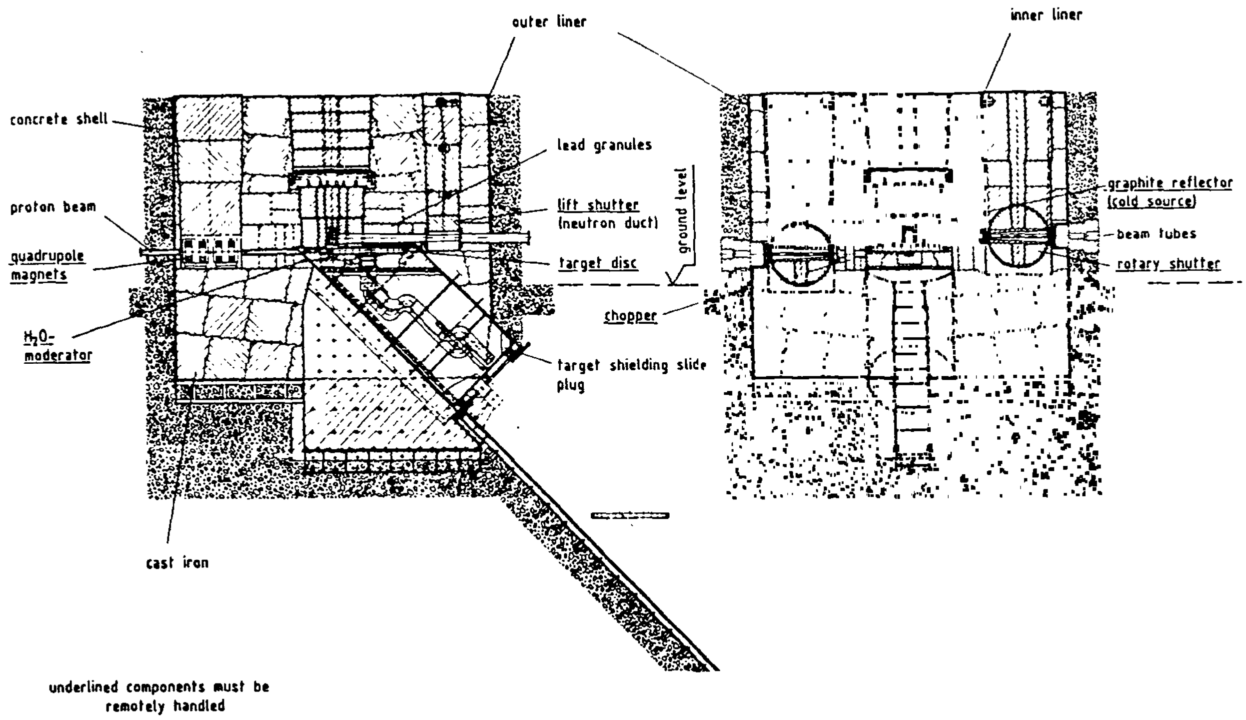

Fig. 1: Target block (vertical view)

2. Target shielding slide plug

The design currently under consideration features a special movable shielding plug with the target disc and KLA-unit fixed on it which can be moved by a hydraulic drive along a slide track inside the cavern which is inclined at an angle of 45° (see Fig. 2). This plug is a steel frame construction of oval or octoangular cross-section in which supply and cooling pipes are imbedded in lead granules for shielding reasons. The plug also carries, the H_2O-fast moderator and its reflector mounted underneath the target disc. The end-plate at the lower side of the plug seals the target cavern (part of the outer liner system). The seal flange of this end-plate is hydraulically placed into the sealing position. All penetrations of pipes and electric cables necessary for supply and measuring are designed vaccum tight. All connections in the design probably will be combined to one coupling device which can be remotely operated.

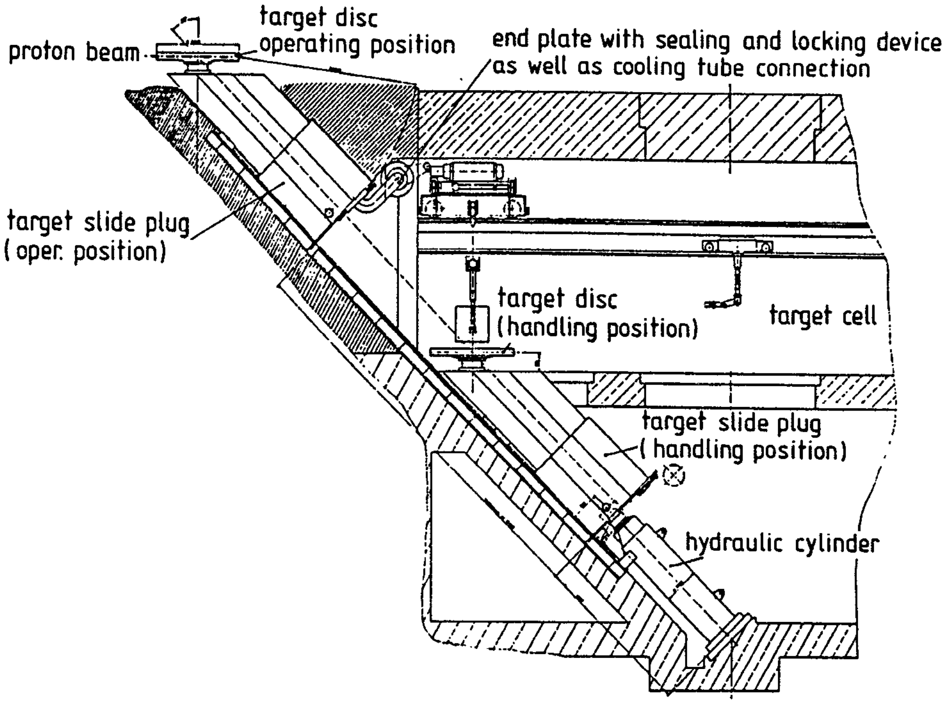

Fig. 2. Target shielding slide plug

In this device the main cooling pipes are arranged concentrically (pressure increasing from inner to outer tube). Alternative designs are being studied at present.

By means of the afore mentioned hydraulic drive (capacity 200 t) the target shielding plug is lowered into the inspection position after disconnecting the connections and locking device. In this position the target disc is in a well shielded cell (target cell) beneath the experiment floor of the target hall. In this target cell all inspection, maintenance and probable repair work as well as replacement or exchange of the target disc and all other components mounted on the plug can be performed by means of the standard equipment of a hot cell.

The feasibility of the tilted arrangement of the target cavern including moving, locking and sealing of the shielding slide plug was demonstrated in a feasibility study carried out by an experienced industrial company.

More information and data of the target shielding slide plug is given in table 1.

- 45° arrangement in a forward direction relative to proton beam, motion on slide track between 2 positions (operation and handling) with special locking (bolts) in upper operation position		
- total weight of slide plug	about	220 t
- dimensions of plug	about	2.5 m octagonal or oval, 6.5 m long
- welded structure		material: mild steel (stainless)
- shielding material		lead granules
- movement by hydraulic drive		
- cylinder force		200 t
- cylinder stroke		12,400 mm
- hoisting and lowering velocity		0.5 m/min
- positioning accuracy of target disc		≤ 5.0 mm

Tab. 1: Target shielding slide plug (essential items and technical data)

3. Target cell

The arrangement, design and geometry of the target cell is presented in Fig. 3. It is subdivided into three areas which are:

- assembly cell,
- workshop cell and
- airlock cell.

The target cell is equipped with a total of 8 pairs of mechanical manipulators. Two pairs each are on opposite sides of the assembly and airlock cell. The other four pairs are mounted in the workshop cell. Each pair of manipulators is mounted above

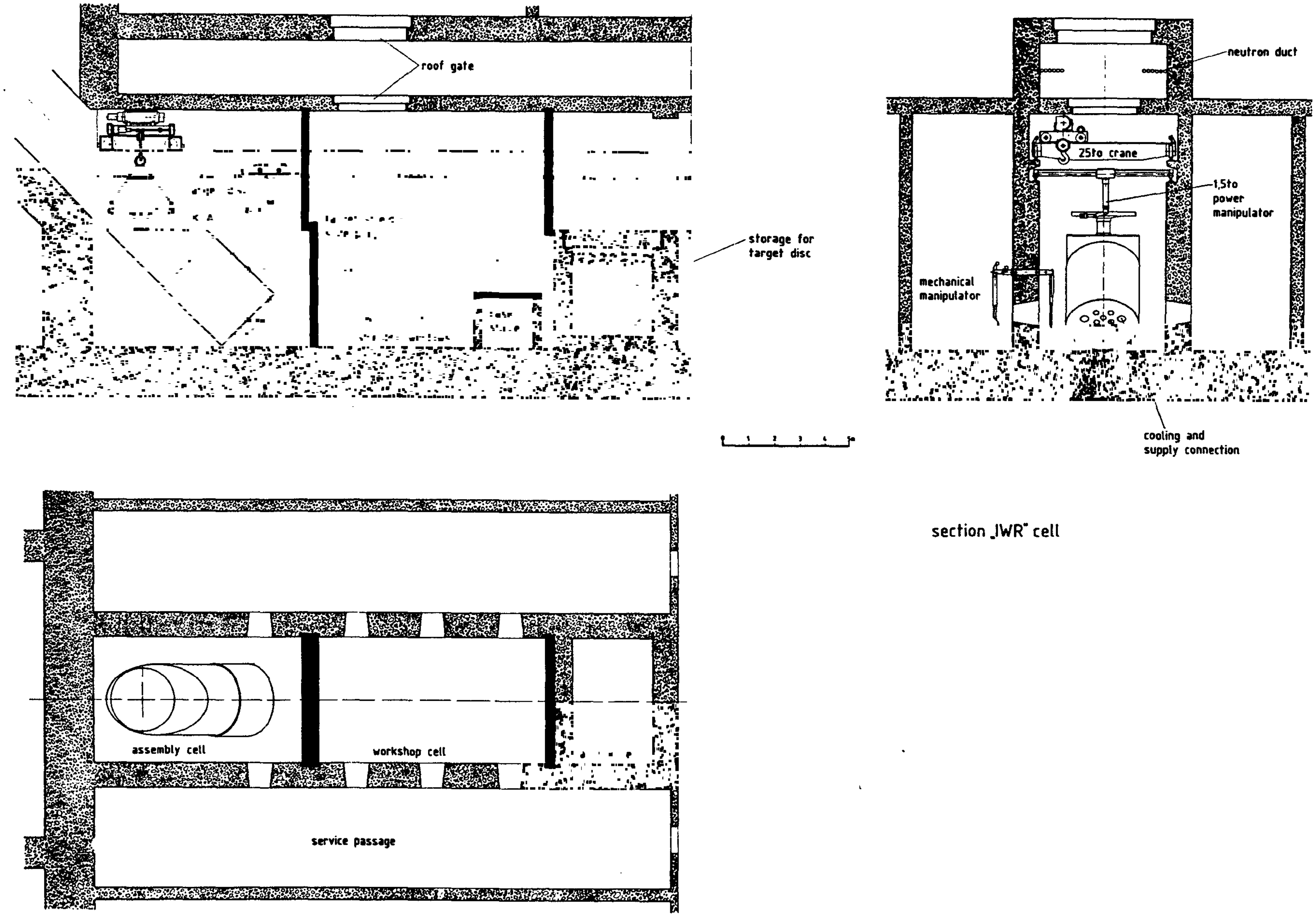

Fig. 3: Target cell

shielding windows in the 1 m thick concrete shielding wall of the cell. In addition there are one retractable viewing plug and wall penetrations in the window frames for supply and control connections into the cell. An overhead crane of 250 KN capacity moves over the total length of the cell.

The basic equipment of the cell also includes a power manipulator with a capacity of 15 KN at the hook of its telescope. The equipment is well proven and available on the market.

Apart from the basic apparatus, auxiliary equipment is needed. These are various tools for maintenance and repair, and also for disassembly especially of the target disc. The type and number of these tools (for instance drilling machines, impact wrenches, cutting machines and so on) will be determined in a test programme which is in progress.

The target cell has several transfer systems, a Padirac system and a one-way system in the workshop cell.

The Padirac-system is already in use in the KFA decontamination department and in the three hot cell facilities thus providing for easy transport to either of the facilities. These will bei used depending on the sort of work to be carried out, for instance waste removal to department of decontamination or post irradiation examination of target rods to the hot cells.

The one-way system only serves to introduce small tools or other items into the cell. Larger components (up to 2.5 m diameter) can be introduced from the target hall into the workshop cell via the cell roof gate.

4. Handling of the target

The uranium target is the most important component as far as the level of radioactivity and afterheat is concerned. Therefore it determines the design of the target cell and special handling procedures. Table 2 presents activity inventory and afterheat data of the uranium target (/4/,/5/), for different times after shut-down of target operation (12000 h, assumed).

Time after shut-down (d)	0	1	5	10	100
Activity inventory (MCi)	45.1	12.6	5.1	3.6	0.8
Afterheat (kW)	415	50	29	20	5

Tab. 2: Activity inventory and afterheat of the uranium target for different times after shut-down (12000 h target operation)

The uranium target will be handled not earlier than 5 days after shut-down of the SNQ target station. At this time the decay heat is about 30 KW, the activity about 5 M curies. Since the corresponding values of the tungsten are significantly lower (about 1/10) the waiting time will be less than 2 days till the target can be moved into the target cell.

The normal H_2O cooling of the target is interrupted during lowering of the target shielding plug into the inspection position and handling of the target in the target cell. Thus the temperature of the target would be increased by about 30 - 40 K per hour under the pessimistic assumption that heat removal (e.g. by conduction, convection or radiation) from the target is not taken into account.

Therefore, after disconnection of the normal cooling pipes (see 2.) the target shielding plug will be connected to a small flexible cooling device that will keep the target at moderate temperatures ($< 100°$ C) during lowering of the plug and afterwards in the inspection position. If later the small cooling device must be disconnected according to the handling requirements a significant portion of the airflow provided by the ventilation system of the target cell can be directed onto the target disc by means of a movable fan in time intervals to cool the target.

It should be pointed out that the afore described cooling is not needed for safety reasons (release of fission and spallation products according to cladding failure of the target rods) because the temperature of the target will not exceed 300° C due to the heat removal by natural convection and to a smaller extent by radiation of heat when the shielding plug is moved in the cavern or the target is handled in the cell. /3/

5. Handling system for the target block

Fig. 4 shows the concept of this system which is necessary for dismantling, remounting and transportation of the components in the wells of the target block. Its main component, a shielded container, has an inner diameter of about 2.5 metres and a height of about 2.6 metres. The second component is a movable shielding gate that is to be placed over the top of the well in which the component in question is located. The shielded container can be equipped with either a hoist and a grip or with a manipulator on a telescope for remotely loosening or fastening the connections of the component and lifting or lowering of the component.

At present a design stud y of the system is being carried out in cooperation with an industrial company.

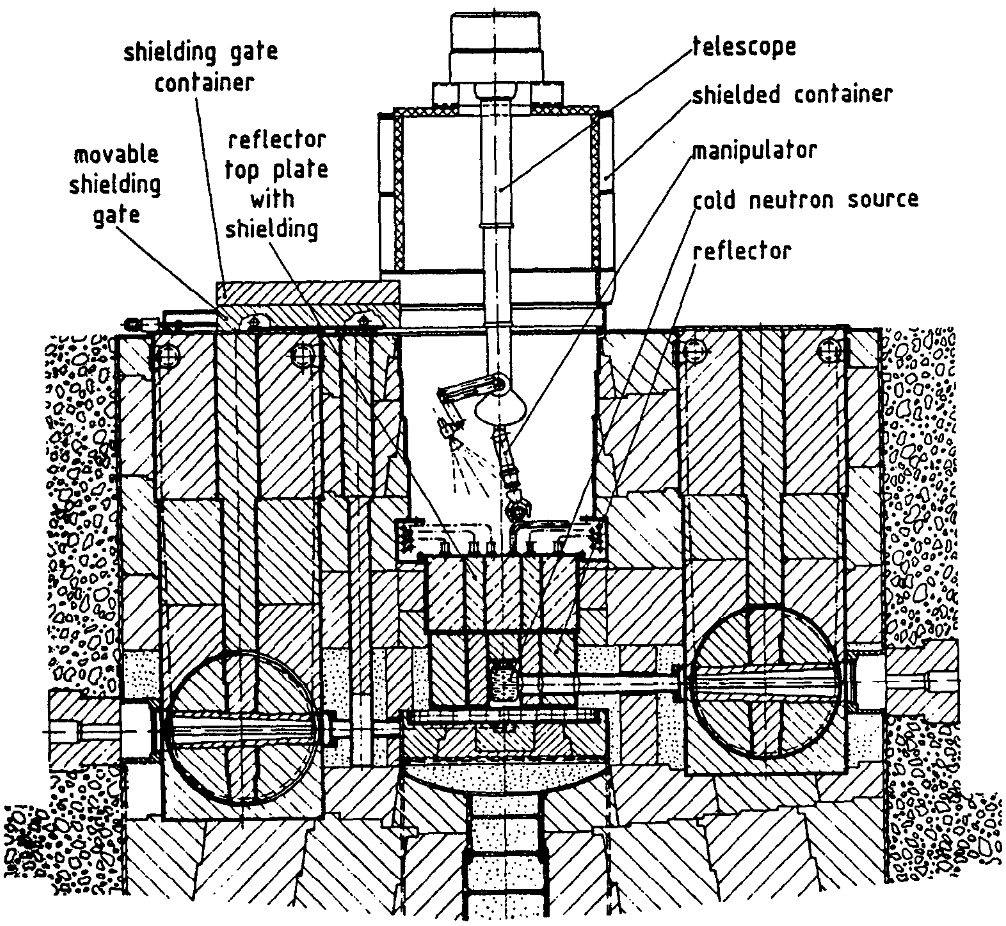

Fig. 4: Handling system for the target block

6. Advanced handling equipment

For the target block handling system, and also for a handling system for accelerator components and of components in the connecting tunnel and close to the target block the design concepts call for advanced handling equipment like robots and/or telemanipulators (electric master-slave manipulators). In a handling test programme both types of equipment have been tested for their suitability. As the main result it can be stated, that for all routine handling operations (for instance preparation for removal of a component) especially adapted robots with the use of programmed control are far more suitable than telemanipulators mainly with respect to speed. Nevertheless it must also be emphasized that in odd cases (deviations from handling routines) a telemanipulator is very useful. An extensive market analysis indicated that out of the large number of types of robots available only a relatively small number of robots combined with appropriate additional equipment seem to be applicable to the requirements for handling in the SNQ. Development of telemanipulators is being carried out in Germany and especially in France. In both cases cooperation with third parties has been initiated. For the SNQ handling test programme in progress a robot has been purchased.

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