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Drobeta Turnu Severin Heavy Water Plant: Functioning and Shutting Down

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Abstract

Due to the special working conditions in the heavy water plant, an extensive research and program has been developed for the operational safety of the installations, based on specific action methodologies and in situ experimental programs for the evaluation of the long-term behavior of materials and installations. After December 1989, the operation of the modules was stopped for about three years, for the modernization of the technological equipment and the surveillance and environmental protection systems. In September 2015, the production of heavy water was stopped and the plant staff was laid off.

Keywords: heavy water plant, Drobeta Turnu Severin, functioning, shutting down

Fabrica de apă grea Drobeta Turnu Severin: Funcționarea și oprirea

Rezumat

Datorită condițiilor speciale de lucru din fabrica de apă grea, s-a dezvoltat un program amplu de cercetare-dezvoltare pentru siguranța în funcționare a instalațiilor, pe bază de metodologii specifice de acțiune și programe experimentale in situ pentru evaluarea comportamentului pe termen lung a materialelor și instalațiilor. După decembrie 1989, funcționarea modulelor a fost oprită timp de aproximativ trei ani, pentru modernizarea echipamentele tehnologice și sistemele de supraveghere și protecție a mediului. În luna septembrie 2015 s-a oprit fabricarea apei grele și a fost disponibilizat personalul fabricii.

Cuvinte cheie: fabrica de apă grea, Drobeta Turnu Severin, funcționarea, oprirea

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Functioning

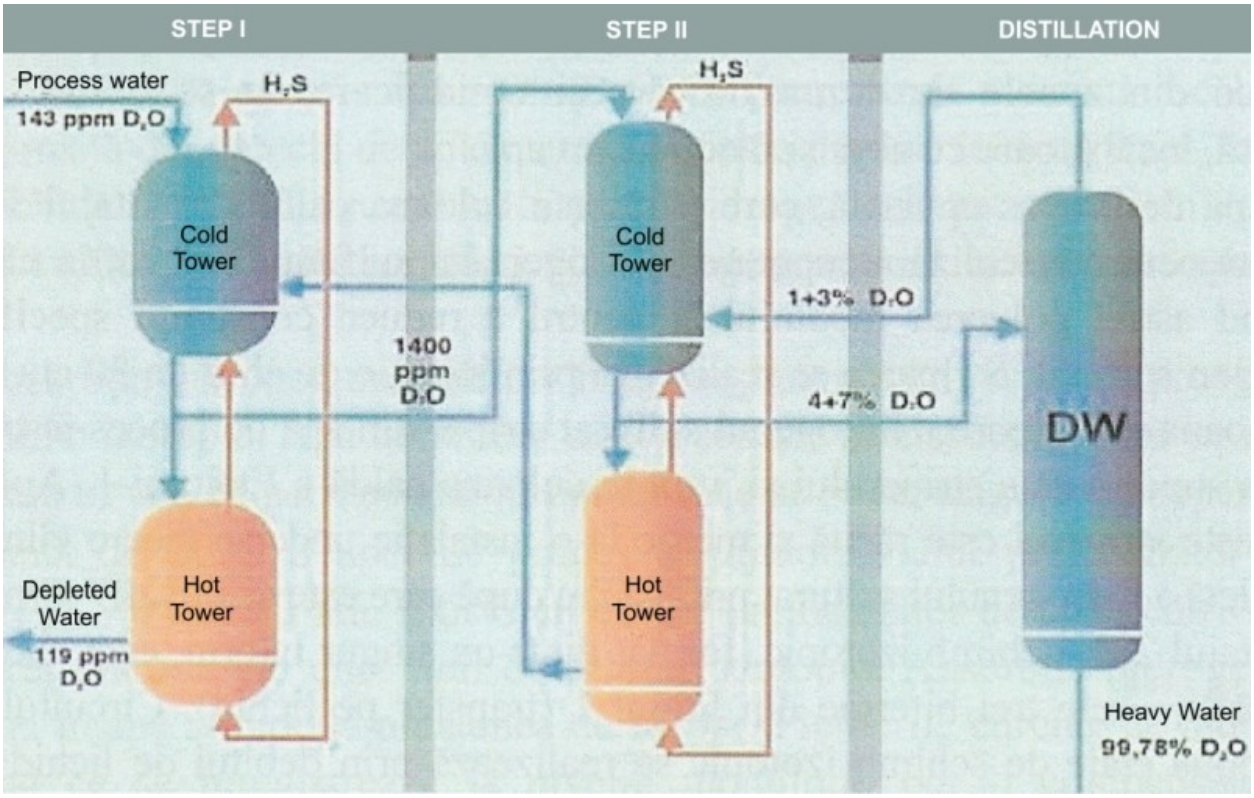

Figure 3. Isotope exchange plant with water distillation. Source: Magazine, no. 7/2008. Translation and editing Nicolae Sfetcu

With the help of the previously prepared sodium sulfide, it was proceeded to the preparation of hydrogen sulfide used in the isotopic exchange with water. The hydrogen sulfide produced was liquefied and stored, followed by pyritization and nitrogen tightness tests, and finally

the start-up of the plant. From the beginning, there were a lot of problems (with interruptions in the supply of steam, for example, or problems with the sieve trays in the isotope exchange towers), which were solved every time by a very close collaboration between the specialists of the heavy water plant and designers (especially IITPIC), and sometimes also scientific and technological research institutes (especially Uzina G). (Turtureanu 2016) There were also differences of opinion between various institutes, such as the large entrainment of liquid at the sieve trays of the cold tower on second step, where Uzina G considered the cause to be the variation of the surface tension of water saturated with hydrogen sulfide, which influenced the hydrodynamics of the sieve trays, (Peculea 2007) while the IITPIC designers considered that the problem was an operation at a pressure lower than the intended one, which influenced the hydrodynamics of the sieve trays. (Turtureanu 2016) Several tests contributed to solving the problem, through collaboration, including the specialists of the heavy water factory (the director at that time was a former colleague of the IITPIC designers).

Due to the special working conditions in the heavy water plant, extensive research has been developed for the operational safety of the installations, based on specific action methodologies and in situ experimental programs for the evaluation of the long-term behavior of materials and installations.

During the construction of the plant, all the welds of the machines and pipelines working in a hydrogen sulfide environment were 100% controlled, and spirometallic gaskets were used at the joints. The walls of the machines and pipes were permanently controlled by the inspectors of the quality assurance service, in a very large number of predetermined points.

All machinery and equipment manufacturers, and all builders, worked in a quality assurance system based on Canadian and American quality assurance standards, with permanent

verification by the beneficiary at inspection and testing points, according to decree 159/1982. The beneficiary itself (the heavy water plant), has developed its own quality assurance system, with a quality assurance manual, execution procedures and its own inspection and testing points, with permanent checks using non-destructive testing laboratory equipment and service inspectors of quality assurance. The development of these documents was a complex and lengthy process, taking into account the complexity of the processes and installations, the increased safety in operation and the high risk for employees and the surrounding population due to the circulation of very large quantities of hydrogen sulfide.

Production of heavy water, in tons per year: (Nică 2016)

- July 17, 1988: the first amount of heavy water: 8,8 tons
- 1989: 22,084 tons
- 1990: 1,266 tons
- 1992: 7,602 tons
- 1993: 40,906 tons
- 1994: 85,217 tons
- 1995: 103, 716 tons
- 1996: 110,2 tons
- 1997: 144,243 tons
- 1998: 146,38 tons
- 1999: 144,657 tons
- 2000: 122,05 tons
- May 10, 2001: Total production of 1,000 tons of heavy water reached
  During the period 1988-1989, the first two modules were put into operation.

"After 1988, the ROMAG staff defines its own development philosophy, gains a lot in the improvement of the operating staff, confirmed by reaching the capacity foreseen by the project, the production of high-quality heavy water and the maintenance of specific consumptions below the levels of international competition." (Glodeanu 2007)

After December 1989, operation of the modules was stopped. Through address no. 20111/1990, the Ministry of National Economy approved the suspension of works on the objective of the Drobeta-Turnu Severin Chemical Plant - Stage II "due to a lack of thermal and electrical energy at the national level", (Nică 2016) and by the Note dated 16.05.1990 ordered the final stop

of the works related to modules 5-8 and their conservation. The plant was scheduled to be shut down for approximately three years, to upgrade technological equipment and environmental surveillance and protection systems. Because of this production shutdown, the heavy water required to start up Unit 1 at the Cernavoda NPP was borrowed from the Canadians, and significant corrosive effects occurred in the plant's facilities.

By GD 147/01.03,1991, the Romag Drobeta Autonomous Region was established. By Government Decision GD 195/April 23, 1992, the factory was transferred to RENEL.

On August 19, 1992, hydrogen sulfide recharging begins and the process of isotopic concentration was resumed. On October 7, 1992, heavy water is obtained again.

By Decision no. 365/1998, the Autonomous Directorate for Nuclear Activities (RAAN) is established by reorganizing the Autonomous Electricity Directorate Renel which, in Annex 2.3, includes the ROMAG-PROD Branch, the ROMAG-TERMO Branch, the Technological Engineering Branch for Nuclear Objectives (CITON Bucharest), and the Nuclear Research Branch Pitesti (ICN Pitesti). By Government Ordinance no. 126/2000 it was approved the continuation of the heavy water production activity by the ROMAG PROD Branch within the Autonomous Directorate for Nuclear Activities, and it was approved the export delivery, to Korea Hydro and Nuclear Power, of the quantities of heavy water produced in addition to the required requirements commissioning of Unit no. 2 – Cernavodă Nuclear Power Plant (16 tons of heavy water). According to the Activity Report of the Romanian Intelligence Service, the import of 335 tons was imposed in December 1994, although this would have been fully necessary only in July 1995, during this period, the Romag Plant producing heavy water which, by postponing the import, would have led to reduce the foreign exchange effort. (SRI 2001)

Decision no. 1259 of November 7, 2002 regarding the approval of the National Strategy for the development of the nuclear field in Romania and the Action Plan for the implementation of this strategy, in which it was stated that "Heavy water is produced at RAAN Romag Drobeta Turnu Severin, based on a process developed of Romanian science and technology, has a high quality, being, probably, the best performing among the existing large quantity offers in the world. The manufactured quantity allows covering the needs of the Cernavoda NPP units without delays." At point 4, it was decided to manufacture the heavy water necessary to ensure technological losses and to put Unit 2 into operation. (Guvernul 2002)

On April 12, 2003, 20 tons of heavy water were sold in China. (Nică 2016)

Through the Supporting Note - Emergency Ordinance for the amendment and completion of the Government's Emergency Ordinance no. 80/2006 regarding ensuring the production of heavy water in order to put into operation and complete the technological needs during the lifetime of units 3 and 4 at the Cernavodă nuclear-electric power plant, it is confirmed the idea that the Autonomous Directorate for Nuclear Activities (RAAN) has as its main object of activity the production of heavy water and technological engineering activities, the production of the amount of 1,100 tons of heavy water by RAAN is approved for the commissioning of units 3 and 4 at the Cernavoda Nuclear Power Plant, and after the production of this amount, the production continues of heavy water to complete the technological needs during exploitation.

> "According to the technical specification of the SNN beneficiary, the "virgin" heavy water produced at RAAN- Romag Prod Branch in Drobeta Turnu Severin has superior quality parameters, this being also demonstrated by the results of the analyzes carried out on the occasion of exports from 2001 - 2004: CNE Wolsung - South Korea, CNE Qinshan - China and Nukem - Germany with CAMBRIDGE ISOTOPES LABORATORIES Inc. - USA, SPECTRA GASES Inc. - USA, ISOTEC Inc. - USA and CHEME UETICOKON. as end users" (Guvernul 2006)

Several specialized studies have shown that the use of heavy water of advanced concentration and purity in reactors leads to quantifiable positive effects, the most important of

which are the increase in fuel combustion efficiency, thus achieving an economy of uranium and decreasing the corrosion rate.

Figure 4. Heavy Water Plant - Overview. Source: ROMAG website

The heavy water, super heavy water and super light water produced at the heavy water plant had the following official specifications:

Qualitative parameters	Value	U.M.
Isotopic concentration	min. 99.78	% wt. D_2O
Conductivity	max. 5	microS/cm
Turbidity	max. 1	NTU(ppmSiO_2)
Organics ($KMnO_4$ demand)	max. 10	mg/kg
Chloride	max. 0.5	ppm
Tritium	absent	microCi/Kg

Table 4. Heavy water technical specifications. Source: (ROMAG-Prod 2014)

The heavy water produced by ROMAG PROD complies with the requirements mentioned by AECL, Technical Specifications TS-XX-38000-001, approved by AECL on 01.02.1990.

Qualitative parameters	Value	U.M.

Isotopic concentration	min. 99.90*	% wt. D_2O
Conductivity	max. 5	microS/cm
Turbidity	max. 1	NTU (ppmSiO_2)
Organics ($KMnO_4$ demand)	max. 10	mg/kg
Chloride	max. 0.04	ppm
Tritium	absent	microCi/Kg

Table 5. Super heavy water technical specifications. Source: (ROMAG-Prod 2014)

* The minimum concentration of the product is specified with the following codes:

Code	Min % wt.D_2O
HG	**99.90**
VHG	**99.96**
EHG	**99.9996**

Table 6. Minimum concentration of super heavy water product. Source: (ROMAG-Prod 2014)

Qualitative parameters	Value	U.M.
Isotopic concentration	max. 80*	ppm D_2O
Conductivity	max. 5	microS/cm
Turbidity	max. 1	NTU (ppmSiO_2)
Organics ($KMnO_4$ demand)	max. 10	mg/kg
Chloride	max. 0.5	ppm
Biological purity	absent	No germs

Table 7. Technical specifications for superlight water. Source: (ROMAG-Prod 2014)

* The maximum concentration of the product is specified with the following codes:

Code	ppm D_2O
SU1	**0 - 20**
SU2	**21 - 40**
SU3	**41 - 60**
SU4	**61 - 80**

Table 8. Minimum concentration of the superlight water product. Source: (ROMAG-Prod 2014)

Romania thus became one of the major producers of heavy water. (Spinei 2020)

Shutting down

The specific social, economic and political problems that arose after the revolution of December 1989, but also the technological problems that arose in the operation of the heavy water plant, some of which were impossible to solve, determined the appearance of critical anomalies that led to a period of crisis in the evolution of the heavy water plant. This is how phase 3 appeared, predicted by Kuhn, in which the crisis can no longer be resolved in the existing paradigm and it is necessary to move towards a new paradigm.

The high quality of heavy water produced by ROMAG PROD was confirmed not only in the operation of the CANDU reactors at CNE Cernavodă, but also by AECL Canada which agreed to grant Romania a loan of 400 t of heavy water to put the first CANDU reactor into operation. The entire amount of borrowed heavy water was returned to AECL with high purity and high concentration. (Ioniţă 2018)

The heavy water was stored in 220-liter inert gas cushioned stainless steel vessels and 50 m^3 tanks, in secure storage.

During the period 1994 - 1998, an inventory of heavy water with the required quality parameters for Unit 1 from CNE Cernavodă (556 t) had already been carried out, and in the period 1999-2004 the necessary heavy water for the first loading for Unit 2 from CNE Cernavoda. Surplus heavy water was exported to countries such as Korea, China, Germany, USA. (Fako et al. 2019)

Emergency Ordinance no. 54 of May 29, 2013 regarding some measures for the reorganization by partial division of the Autonomous Directorate for Nuclear Activities Drobeta-Turnu Severin and the establishment of the Autonomous Directorate of Technologies for Nuclear Energy - RATEN decides to establish the autonomous authority of strategic interest, the Autonomous Directorate of Technologies for Nuclear Energy, hereinafter referred to RATEN, through the partial division of the Autonomous Directorate for Nuclear Activities Drobeta-Turnu

Severin, hereinafter referred to as RAAN, without ceasing its existence, through the separation of research, development, technological engineering and technical support activities for nuclear energy and its moving to RATEN.

In 2013, based on Government Decision no. 85/2013, the heavy water plant goes into insolvency. In January 2014, the Judicial Administrator, S.C.P. Tudor and Associates developed the RAAN activity reorganization plan, the factory being completely shut down at the end of 2015.

GEO no. 20/2015 for establishing the maximum level of the heavy water product intended for units 1-4 at the Cernavodă Nuclear Power Plant for the entire period of their exploitation, as well as for the management of heavy water (Official Monitor no. 433 of 17.06.2015) considers that the further purchase of heavy water is no longer justified. The quantities of heavy water produced by the Autonomous Directorate for Nuclear Activities Drobeta-Turnu Severin until June 30, 2015 in order to reach the maximum levels provided for in art. 1 will be taken over to the state reserve by the National Administration of State Reserves and Special Issues.

In September 2015, the production of heavy water was stopped and the plant staff was laid off. By Sentence no. 10/28.01.2016 pronounced by the Mehedinti Court in file no. 9089/101/2013, it was ordered to start the bankruptcy procedure and to dissolve the debtor RAAN, sentence made final by Decision no. 563/14.06.2016 of the Craiova Court of Appeal. Eurolnsol SPRL was appointed judicial liquidator.

Since the heavy water management activity was left without funding sources, the heavy water management was ensured by RAAN, through the ROMAG - PROD Branch, with a number of approx. 96 employees, specialized staff, (Ministerul Energiei 2015) the National Heavy Water Management Center was established, an institution under the Ministry of Energy, with the following objectives established by OG 29/2017 and HG 914/28.12.2017: keeping the inventory

of heavy water which is the object of the deposit and/or administration, the provision of technological and protective measures to maintain its integrity; taking over from RAAN the technical archive, including the classified documentation, regarding the installations, technological flows, technical prescriptions related to the production, storage and maintenance of the physico-chemical properties of heavy water; and obtaining and maintaining all the approvals and authorizations necessary for carrying out activities related to heavy water management, according to the legal provisions in force. (C.N.M.A.G. 2018)

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