APPLICATION OF AMERICAN AND FRENCH RULES FOR THE NEXT BELGIAN PWR

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ABSTRACT

The licensing practice in Belgium is evolving from the precedent compliance with the USNRC rules (as applied to the 4 last Belgian PWRs) to a more sophisticated approach applied to the next Belgian PWR (N8), which incorporates a mixed compliance with the USNRC or with French rules, depending on the equipment, the structure or the system considered. In this paper, we present the approach concerning the licensing rules applicable to N8. The following aspects are covered:

- rules applicable to the NSSS
- rules applicable to the BOP (codes of design for systems and structures)
- rules applicable to the equipment (code of construction for mechanical and electrical components)
- impact on the lay-out of the plant.

Some examples of application of this methodology are given.

THE LICENSING OF NUCLEAR POWER PLANTS IN BELGIUM

Seven commercial nuclear power plants are now operating in Belgium, all of them of the PWR type. They are located on two sites, Doel in the northern part of the country, and Tihange in the southern part, and belong to the 900-1000 MW three-loops class of reactors, except the first two ones on the Doel site, which are twin two-loop units with an output of 2 x 400 MW. Four units use WESTINGHOUSE reactors and two units FRAMATOME reactors, while one unit uses a reactor designed by a W-FRA consortium.

All those units have been designed, constructed, erected and commissionned in accordance with the American technical regulations, between the late sixties and 1985. The parties involved in the Belgian nuclear program were indeed convinced that the size of this program was not large enough to warrant developing in Belgium a set of nuclear technical rules, and that it was better to rely on an existing consistent set of such rules. The American nuclear regulation seemed at that time to be the most useful, since it was one of the most complete ones, was readily available in writing and, last but not least, was the regulation against which the Westinghouse NSSS had been designed.

More than ten years after launching of the Belgian nuclear program, the initial decision of using the American regulations appears to have been a wise one, since it allowed the whole nuclear industry to have a well-known licensing basis, even though the unusual publication rate in the U.S. during the years 75 and following caused some problems to it.

The next Belgian nuclear power plant project (the so-called N8 plant), which is expected to be launched in the near future, makes use of a 1400 MW reactor of the most recent French type, the first of which is being erected at Chooz.

The problem which the Belgian utilities were faced with was then the following one: would they propose to the Safety Authorities to continue with the well-known American regulations, or should they change for the French regulations, which have been developed for more than ten years and which have now reached a significant level of completeness?

In 1985 then, together with the conceptual study of the N8 plant was started a review of the French rules.

A review group was formed in order to gain knowledge, with the help of EdF representatives, of all rules and practices applied in the French plants, as accepted by the French Authorities.

The technical content of those rules was examined in detail, as well as the administrative content of them i.e. the way the various French Authorities deliver the necessary authorizations.

THE TECHNICAL RULES

When comparing two different national regulations, it is worth separating technical rules in two categories: the rules related to systems and those related to specific components. A third category can also be distinguished for

Quality Assurance rules.

Among the rules related to systems, one can mention the rules on high energy line breaks, on fire protection, on safety classification and the one on beyond design (supplementary) situations.

No big divergence was identified between the two systems, the American and the French ones, concerning those rules. The high energy line break philosophy is close to identical in both systems; the classification principles are also quite similar and lead to systems designed to basically the same quality standards. Fire protection principles are the same, but realization may differ, which is understandable, if we take due account of the separate experiences in this field in separate countries. Accounting for events beyond design results in France from reliability calculations. One may think therefore that for a new reactor design in the US, the equivalent kind of protection would be imposed against those events, as an outset of the probabilistic risk assessment which is now requested by the US regulation.

Concerning the rules related to specific components, let us mention the rule on component qualification to accident conditions and the construction rules of mechanical components (RCCM versus ASME).

Again, it was found that those rules were equivalent in the two systems of regulation: both systems treat the same questions on material qualification, and both systems deal with construction problem very similarly, to such an extent that they will be both accepted as design and construction codes for the components of the next power plant.

Finally, concerning Quality Assurance, no significant difference can be demonstrated between the French and the American practices. For example, FRAMATOME bases its QA program on IAEA code of practice, which is compatible with the American 10 CFR 50 Appendix B.

THE ADMINISTRATIVE RULES

Those rules define all responsabilities of the various authorities and the relationships between them. Since the Belgian structure of the Authorities is different from the French one, it is of no interest to apply the same administrative rules. Therefore, to cover those administrative aspects when either the American or the French codes are used to construct mechanical components, and using the fact that those codes are quite similar, the related administrative aspects will all be treated by a single document, which is adapted to both of them.

APPLICATION TO THE N8 PLANT

As a result of this review of the French rules, and taking into account the 15 years long use of the American rules by the Belgian industry, the decision was made to apply the American rules on a general basis, with a major deviation for the NSSS, which will use the French rules in order to safeguard the proved design of the French product.

In addition, use of either the American or the French rules will be allowed for the construction of individual components, whether electrical, mechanical or civil work.

This decision was made because
1) it would have been detrimental to the whole Belgian nuclear industry to switch now to a new licensing reference, having used the American reference since the very beginning of the Belgian nuclear program, and
2) BELGATOM could demonstrate a good compatibility between the French and the American rules.

As far as component codes are concerned, a quite detailed comparison was performed, which showed that no important problem would result from the use of the two codes in two adjacent components, provided an interface management program is properly implemented.

EXAMPLES OF DIVERGENCE BETWEEN THE BELGIAN N8 PLANT AND THE FRENCH PRACTICE

The following significant examples are given, where the French rules and/or practices have not been followed, either due to specific Belgian site related requirements, or to specific requirements from the Belgian Authorities:
- protection against external accidents,
- confinement of radioactive products in case of a LOCA,
- structure of the safety injection system and of the containment spray system.

PROTECTION AGAINST EXTERNAL ACCIDENTS

The Belgian industrial and aerial environments are generally very densely used and therefore protection against external accidents induced by this environment is necessary, should protection be deemed necessary at a probability level of the order of 10^{-6}/year, which is now the case in many national regulations for any new project. The French environment is significantly less densely used and therefore the threats resulting on the French plants are very significantly reduced with respect to the Belgian plants.

The French plants are designed for the crash of a small civil airplane and for a small overpressure of 10 kPa provoked by a gas cloud explosion; the Belgian plant has to be protected against a crashing military fighter (of the F16 class), a crashing civil airplane (of the Boeing 727 class) and a reflected overpressure of 45 kPa resulting from a nearby deflagration.

The military fighter is characterized by a mass of 14,6 tons crashing at 150 m/s with an equivalent impact area of 2,6 m^2, while the civil airplane is characterized by a mass of 91 tons crashing at 103 m/s with an equivalent impact area of 28 m^2.

Those impacts compare as follows with the ones considered in France:
- a twin engine general aviation aircraft weighting 5,7 tons crashing at 100 m/s with an equivalent impact area of 12 m^2;
- a single engine general aviation aircraft weighting 1,5 tons crashing at 100 m/s with an equivalent impact area of 4 m^2.

It is seen that the differences in the impacts are such that hardening of the structures is necessary in Belgium (bunkerization) while it is not in France, since the normal concrete thicknesses are capable of withstanding the impacts described.

Considering, in addition, that the decision was made not to use dedicated protection systems in case of an external accident, as it has been implemented in the four previous Belgian plants, we had to change significantly the lay-out of the French plant and to develop a new one, characterized by the complete protection (bunkerization) of the reactor building, the spent fuel building and the auxiliary and electrical buildings: see figure 1.

Main steam valves and main feedwater valves are also protected against those impacts by a protective shield attached to the reactor building.

Diesels are housed in buildings which are protected against the gas cloud explosions overpressure, while protection against airplane crash is assured through physical separation of the diesel buildings.

CONFINEMENT IN CASE OF A LOCA

The French practice for design basis accidents confinement is to consider that only the activity contained in the fuel-clad gap of the fuel rods is amenable to release into the containment atmosphere.

The Belgian practice is to take a source term inside containment equivalent to a full core meltdown. This, together with dose limits at the site fence lower than the French ones (typically 0.10 Sv whole body for the whole duration of the accident against 0.15 Sv for the first two hours after the accident) have led to the choice of sophisticated containment safeguards: a containment liner, a double containment with recirculation and filtration of the atmosphere inside the annulus between the two concrete containments, and with filtration of the air released to the stack, a system allowing the radioactive releases from the LOCA recirculation loop to be recycled through the double containment annulus, and finally a seal system on all large containment isolation valves.

STRUCTURE OF THE SAFETY INJECTION SYSTEM

The safety injection system, both in the American and the French safety philosophy, must comply with the single failure criterion.

A three train system has been incorporated in the last 4 Belgian nuclear power plants. Nevertheless, a two-train system may also be acceptable, provided all injection lines into the different loops are interconnected, both in the high pressure and in the low pressure systems, and provided it can be shown that no bypass occurs in any case of primary break.

However, the Belgian Authorities did not accept this philosophy, arguing that small breaks were much more probable than large breaks and that redundancy should be enhanced for those cases.

As a consequence, the safety injection system of the N8 plant will have the following structure (fig.2):
- 4 High Head Safety Injection pumps, connected to one HHSI header delivering water to the four primary reactor coolant loops. Each HHSI pump may be supplied by an independent diesel generator.
- 4 Low Head Safety Injection pumps connected to one LHSI header, delivering water to the four primary reactor coolant loops. Each LHSI pump may be supplied by an independent diesel generator.
- The valve arrangements in the suction lines from the sump and from the RWST are designed according to the single failure criterion, on a 4 active train basis.
- The steam dump to the atmosphere is designed as a safety grade system in order to allow the depressurisation of the reactor coolant system and the use of the LHSI system as a redundancy of the HHSI, in case of a single passive failure of the HHSI header.

The supporting systems such as the component cooling system are also designed on an enhanced reliability basis (4 X 100 % are installed, with 2 X 100 % running and 2 X 100 % on standby).

The electrical systems are designed on a 4 train basis, including four independent, air-cooled, diesel generators.

OTHER FEATURES

It is worth noting also that the applicant has deterministically incorporated other features into the design, in order to make sure that the same level of protection was afforded as in the 4 units of the previous generation.

Those features include, for instance:

- An improved auxiliary feedwater (AF) system that incorporates (fig. 3):
  - . 4 electrically driven pumps (50 m^3/h)
  - . 2 turbine driven pumps (100 m^3/h)
  - . 2 AF water supplies (1400 m^3)
- An improved dedicated RCP seal water injection system, incorporating two electrically driven pumps. In addition, the existing traditional CVCS hydro-test pump may also be supplied by a dedicated turbo generator in order to provide a diversified capability of injecting seal water in the RCP seals.

CONCLUSIONS

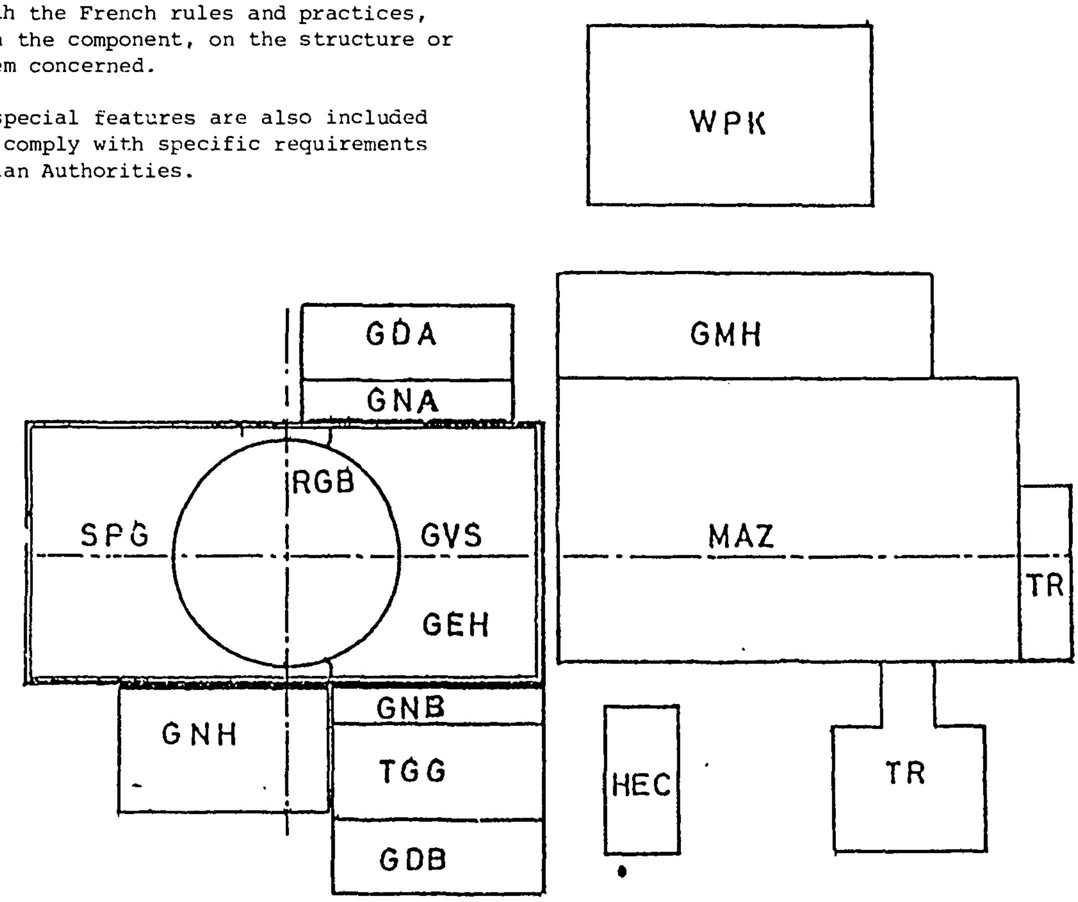
As far as compliance with the regulations is concerned, the next Belgian PWR (N8) will be designed according to a sophisticated approach, which incorporates a mixed compliance with the USNRC or with the French rules and practices, depending on the component, on the structure or on the system concerned.

Some special features are also included in order to comply with specific requirements of the Belgian Authorities.

Fig. 1

N8 General lay-out

GDA,B	Diesels buildings
GEH	Electrical building
GMH	Mechanical auxiliaries
GNA,B	Electrical buildings (non-safeguards)
GNH	Auxiliary building
GVS	Auxiliary building (safeguard part)
HEC	Safeguard cooling tower
MAZ	Turbine building
RGB	Reactor building
SPG	Fuel building
TGG	Access building
TR	Transformers
WPK	Cold workshop



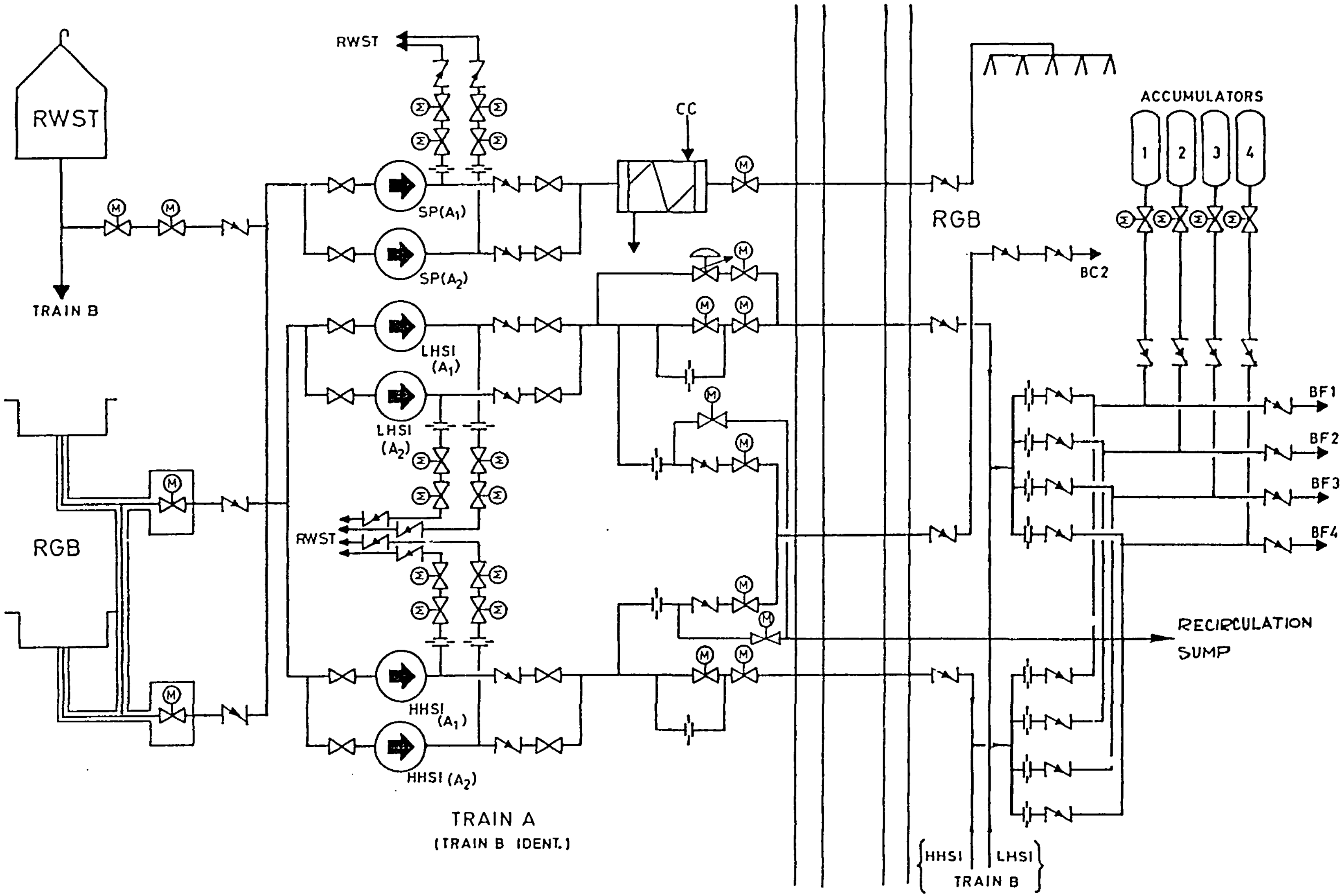


FIG. 2

N8 _ SAFETY INJECTION (SI) AND CONTAINMENT SPRAY (SP) SYSTEMS

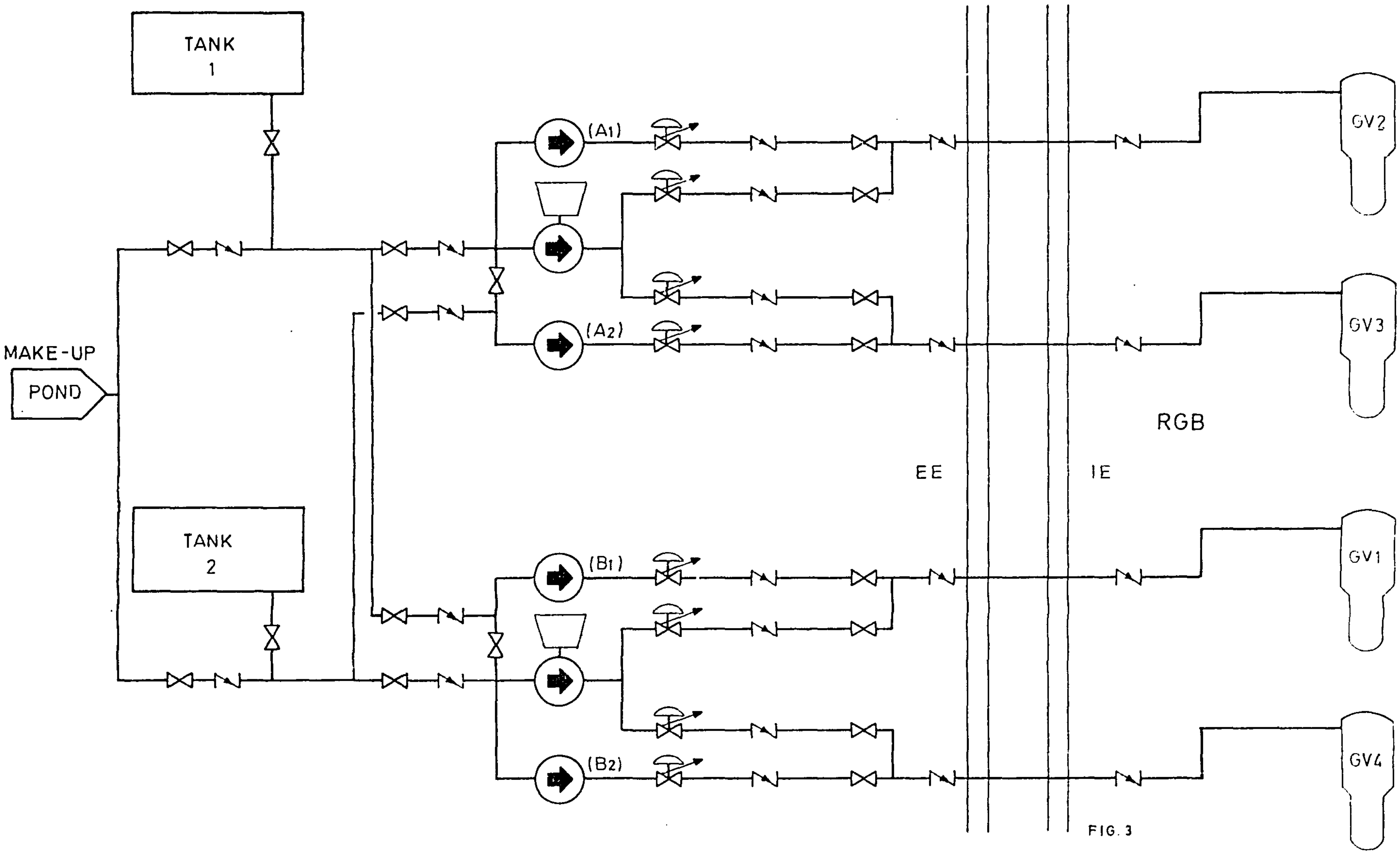


FIG. 3

N8 _ AUXILIARY FEEDWATER SYSTEM (AF)