NATIONS UNIES	ОБЪЕДИНЕННЫЕ НАЦИИ	UNITED NATIONS
COMMISSION ECONOMIQUE POUR L'EUROPE	ЕВРОПЕЙСКАЯ ЭКОНОМИЧЕСКАЯ КОМИССИЯ	ECONOMIC COMMISSION FOR EUROPE
SEMINAIRE	СЕМИНАР	SEMINAR

COMMITTEE FOR TRADE, INDUSTRY AND ENTERPRISE DEVELOPMENT

Distr. GENERAL

AD HOC GROUP OF EXPERTS ON STEEL

TRADE/STEEL/SEM.2/AC/6

Workshop on Radioactive Contaminated Metallurgical Scrap

15 April 1999
ENGLISH ONLY

Prague (Czech Republic), 26-28 May 1999

CONTROL OF RADIOACTIVITY AT THE LUXEMBOURG STEEL - MAKING FACILITIES

(Prepared by Ch. Werner, ProfilARBED S.A., Luxembourg)

This paper has been issued without formal editing by the secretariat

All type of recycling industry has to deal with tramp materials accompanying its feedstock. There is no exception for the steel recycling industry despite the excellent possibilities of magnetic separation to process steel scrap to a rather pure raw material for secondary steel-making. In our industry the tramp materials not only include metals and organic compounds used for processing and coating purposes but also items used in association with the steel during its useful life. Scrap based EAF steel-making is affected by such tramp substances which end up in the metal, in the slag or in the fume emitted by the furnace.

Since we are dealing with steel, a material with universal and versatile usage, the presence of radioactive tramp material in or on the scrap that we are bound to recycle is not unlikely.

1.1 Different origins of potential radioactive contamination of steel scrap.

Radioactive substances found in scrap can have different origins:

- Contamination or activation levels acquired during the useful life of steel within civil and military **nuclear installations** such as enrichment facilities or fuel reprocessing plants as well as all types of nuclear reactors and power stations including submarines. Although dismantling procedures of these types of facilities aim at channelling contaminated material to proper processing or disposal it cannot be excluded that steel scrap from such origins enter the common scrap market. A multitude of different isotopes resulting from activation and decay can be present, such as ^{51}Cr, ^{54}Mn, ^{55}Fe, ^{60}Co and ^{63}Ni.
- Presence within the scrap of **discreet radioactive sources** used in industrial and medical applications. Most frequently used isotopes are: ^{60}Co, ^{137}Cs, ^{226}Ra, ^{241}Am, ^{192}Ir and ^{90}Sr. Generally such sources are contained in their protective lead shielding and radiation levels perceived outside are very low although the sources may have very high energies.
- Presence of **natural radio-nuclide (NORM)* deposits** accumulated during the useful life of steel parts used in mining, oil drilling and the chemical industry. (Typical isotopes: ^{226}Ra and ^{232}Th)
- Presence of **radioactive coatings** deposited on steel parts used in particular applications (static eliminators, lightning conductors, smoke detectors - generally ^{226}Ra or ^{241}Am).

1.2 Behaviour of radioactive contamination during the steel-making process.

The physicochemical properties such as the boiling temperature and the affinity for oxygen of the nuclides in presence condition their distribution into the processing phases in the melt shop: the metal bath (Co, Mn, Fe, Ni), the slag (Fe, Ra, Th, Cs,..) and the fume (Cs). The distribution factors of the main nuclides expected to enter the steel-making process are shown in table 1.

Once the radio-nuclides are either in the steel, in the slag or in the flue dust they will go on radiating for a long time: according to the characteristic half life times of the different isotopes. Other important characteristics are the activity of the source (measuring unit: Bequerel (Bq) i. e. the number of disintegrations per second) and the energy of the emitted radiation.

Element	Name	Distribution factor			Isotope characteristics		
		Metal	Slag	Fume (Dust)		Half life Years	Energy keV
Mn	Manganese	**1**	0.1	0.05	^{54}Mn	0.855	
Fe	Iron	**1**	0.1	0.05	^{55}Fe	2.68	
Co	Cobalt	**1**	0.01	0.005	^{60}Co	5.27	1250γ
Ni	Nickel	**1**	0.01	0.001	^{63}Ni	125	β
Sr	Strontium	0.1	**1**	0.1	^{90}Sr	2.81	540β
Cs	Cesium	0.001	**0.1-0.5**	**0.5-1**	^{137}Cs	30	662γ
Ir	Iridium	1	0.01	0.001	^{192}Ir	0.2	561γ
Ra	Radium	0.1	**1**	0.1	^{226}Ra	1620	800γ
Th	Thorium	0.1	**1**	0.01	^{232}Th	$1.4*10^{10}$	55γ
Am	Americium	0.1	**1**	0.001	^{241}Am	432	60γ

Table 1: Distribution factors of nuclides into metal, slag and fume (dust)
Half life times and energy of major isotopes

Since some incidents of melting radioactive sources in EAF operations in the United States caused headaches and appreciable cost to some melt-shop operators in the early eighties, the industry realised that it had to protect itself by addressing the matter of radioactivity control with all possible seriousness.

The liability towards our workforce, our shareholders, our customers and the environment make nowadays a radioactivity control at the melt-shop inevitable.

- As plant operators we are bound to assure a safe working environment to our personnel.

- Disposal of contaminated products and by-products as well as the cleanup of radioactive contaminated plants may amount to million □ figures.
- The concern for the integrity of our product is most important for the potential spreading of undesired contamination towards the public and for the suitability of steel for its manifold applications.
- Avoiding environmental contamination through airborne particles or by-products should also be a matter of concern to plant operators.

2. Luxembourg's steel industry's response to the potential radioactive contamination in steel-making.

In 1993, when the Luxembourg steel industry started to implement its plans for an increased usage of scrap as a raw-material for steel-making, the Radiation Protection Agency of the Ministry of Public Health raised the issue of possible radioactive contamination of steel through input materials. This initiative followed the efforts of the European Union towards a sound dismantling of ageing nuclear power stations but was also prompted by cases of detection of radioactivity in scrap imported from Eastern European countries into the European Union.

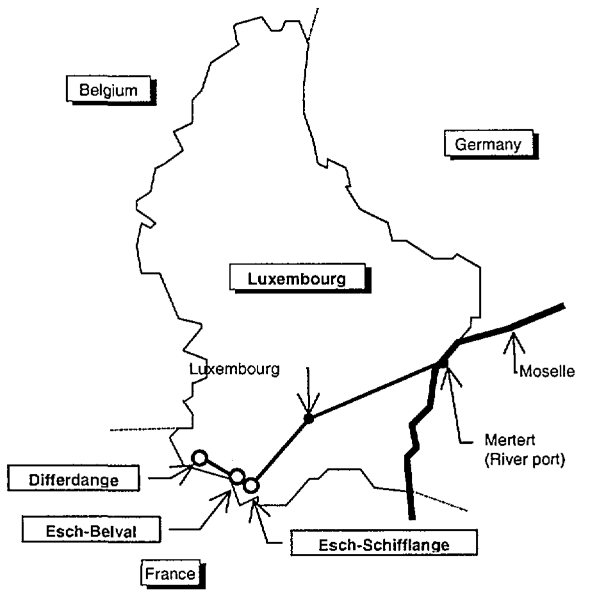

Figure 1: Location of the steel-making sites in Luxembourg

The **Luxembourg steel industry** has a total steel-making capacity of roughly 3 million metric tons per year and operates 3 electric arc furnace plants located in the south-western part of the country (Figure 1)

- <u>ProfilARBED Differdange</u>, specialised in heavy section rolling
- <u>ProfilARBED Esch-Belval</u>, specialised in sheet piling and medium sections
- <u>ARES Esch-Schifflange</u>, supplier of billets for bar mills

From a traditional steel making country, the production of which was based for more than a century on local iron ores Luxembourg has become one of the major EAF operators in Western

Europe through a profound restructuring scheme that started in 1993. Our move meant an increased scrap usage and thus an increased potential for radioactive contamination to get into the plants. It has been decided, thereupon, to install radioactivity checking devices at the gates to the three steel-making sites.

We did however not limit our control scheme to the checking of incoming scrap, but also chose to perform systematic measurements of radioactivity on our products (steel and slag) in order to be able to react promptly to any incident that might occur in the unlikely event of a radiation source escaping the monitoring system.

2.1 Monitoring systems for incoming scrap shipments

More than 98% of our scrap supply comes from abroad. The prime suppliers are, in order of importance, Germany, France, Belgium and The Netherlands. Transportation is done both by road and by rail to the three steel-making sites. Some scrap is carried by barges to the river port of Mertert located on the Moselle-river and gets from there to the steelworks by rail and by truck.

A first and easy step was taken by inserting, into the **purchasing specification for steel scrap**, the clause that shipments should be exempt of radioactive materials. This precaution sets the basis for refusal of any shipment in which radioactivity is traced.

After comparing 6 different **hardware systems** it was decided, on basis of both technical and commercial considerations, to use the BICRON ASM-6000E system with 4 plastic detectors (122*46*5 cm) with a total useful measuring volume of 98340 cm^3.

With these systems measurements can be performed while the carriers are moving at a speed of up to 10 km/h.

Truckloads are checked at the gate of the plant right as they accede to the weigh-bridge. Railway cars are checked at the single access track connecting the public rail system to the in-plant railway network. Care has been taken that the detection takes place before the carriers enter the premises of the steelworks and are still formally within the supplier's responsibility.

The river port of Mertert, which is actually a remote unloading and storage facility of our melt-shops represents a weak point in our control scheme. Since no suitable detector has been available up to now for checking shiploads, we are not in a position to check the scrap that enters our ownership through this point. Of course our detection devices are used as shipments from the port enter the steel-making sites but identification of the origin of the scrap loads is often impossible since an important part of the scrap transits the storage area at the port. As a consequence we have to deal with any radioactive material detected in this scrap and dispose of it at our expense. We are following the development of detecting devices and hope to be able to install a suitable system to check shiploads in the near future.

2.1.1 Measuring fundamentals

The natural radioactivity of steel is very low and, with a good detecting device, it is easy to detect the slightest contamination. Generally the radiation emitted by steel is below the background radiation conditioned mainly by the radiation from the local soil. As a matter of fact, the steel is a shield for the background radiation. At our locations the background radiation of approximately 150 nSv/h gives a reading by the detectors on standby of ~6000 cps. If a load of uncontaminated steel scrap is engaged between the detectors the reading drops to about 4500 cps.

Any γ-ray source will be superimposed to the signal and an alarm will be triggered if the reading exceeds the background reading with statistical significance (i.e. by 4.5 times its standard deviation).

This alarm level can be considered as very low but is justified considering the level of radiation perceived from a source in its protective lead shielding radiating through 1.5m of steel scrap and the walls of a standard scrap truck or railway car. For instance a 37 Gbq (1Ci) source in its typical steel and lead shielding encasement of approximately 140 mm, embedded in a scrap load will cause a dose level of between 20 and 100 nSv/h at the detectors (or a reading of 800 to 4000 cps) - a lower level than the general background.

2.1.2 Procedure for the control of radioactivity on incoming scrap shipments.

The procedure for the management of alarms from the monitoring gates has been developed in close co-operation with the Radiation Protection Agency. A decision flow sheet is shown in figure 2.

All trucks and railway cars are automatically checked as they pass through the measuring gate. If the emitted radiation is lower than the alarm set-point the shipment is accepted.

If, at one point of the load, the measurement exceeds BKG+4.5σ (SET) a sound alarm is given and the printer connected to the measuring system will print a measuring report showing the figures of BKG (background) and SET as well as HIGH and LOW measurements. It also prints a profile showing where along the vehicle high radiation has been measured (Figure 3).

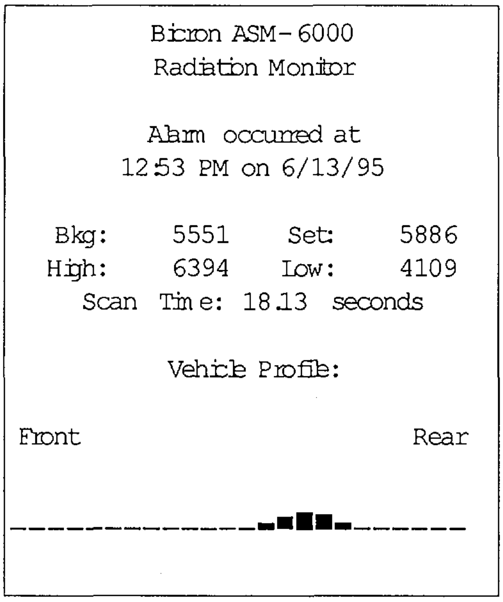

Figure 3: Print-out of monitoring system

Following a relatively low level alarm, which possibly could have been conditioned by a sudden variation of the background signal, a confirmation measurement is to be performed after several minutes.

If the alarm is confirmed, the shipment is refused and access to the premises is denied. The incident is immediately reported to the Radiation Protection agents who take the shipment under their authority and order it to be put into quarantine. For this purpose a special, fenced area has been assigned inside the plant boundaries.

Distinction is made between level 1 alarms (signal < 10*BKG) and level 2 alarms (signal > 10*BKG). In case of a level 2 alarm, access to the proximity of the shipment will be restricted, since the radiation level is potentially hazardous.

The supplier of the contaminated shipment is notified and requested to recover his property once all the formalities for such a transfer have been cleared. Prior to this clearance, further measurements with special equipment will have been performed by our radiation protection specialist crew and by the Radiation Protection Agency in order to collect as much information as possible on the source and the radiation emitted by the shipment.

As indicated before, the vast majority of shipments are not yet in the melt-shop operator's ownership, as the measurements are performed. If, for whatever reason (scrap transited through the Mertert port) this is not the case, shipments are carefully unloaded at a remote location under surveillance of the Radiation Protection agents.

2.2 In-plant control of radioactivity

While radioactivity control of incoming scrap has become a must for steel recycling activities, it is, however, not a 100% protection. Many incidents of melting radioactive sources in arc furnaces, despite this control, have been reported.

Further controls inside the melt-shop have been suggested. Detection of ambient radioactivity by systems similar to those used in nuclear power stations seem to be too sophisticated and costly for steel-making sites.

An affordable system for melt-shops is to check the steel and slag samples as they pass at the melt-shop laboratory. This additional control has been implemented in our melt-shops in July 1996.

The samples which are systematically checked for radioactivity are those analysed for operation control purposes: the last steel sample taken from the furnace prior to tapping and the slag sample taken at slag tapping.

An exhaustive procedure has again been developed together with the Radiation Protection Agency in order to prevent excessive exposure of the melt-shop staff and contaminated products and by-products from being shipped to customers or processing plants. (Figure 4)

Alarm level 1 is attained when the signal is higher than twice but lower than 10 times the background signal (the average of several hundred measurements on previous samples). In such case there is no immediate hazard and the operation of the melt-shop continues normally. The cast semi-finished products from the heat are stored separately while the slag will be put aside in the slag pot until complete solidification. The samples, which triggered the alarm, are brought to the laboratory of the Radiation Protection Agency together with dust samples from the bag house, where the activity is measured and the nature of the nuclides is identified.

The further use of the steel and/or the slag will depend on the results from those measurements.

If the signal exceeds 10 times the background reading, the radiation level is considered as potentially hazardous. In such case Radiation Protection agents will come to the site at once in order to measure the dose levels close to the ladle and to give instructions for further processing of the heat. Precautions will be taken at casting: Operators will carry dose meters and will be instructed to stay as far away as practicable from the radiating steel. The Radiation Protection agents will also take measurements inside the melt-shop and production will be halted until clearance is given by them.

The destination of the contaminated product, again, will depend on the final results from the Radiation Protection laboratory to which steel, slag and dust samples will have been rushed immediately after the alarm occurred.

2.3 Monitoring of the flue dust from the melt-shop.

The above described in-plant measuring would, most likely, not be useful in the event of the melting of a Cesium 137 source, since this element would most likely end up in the flue dust from the EAF. In order to close this gap, a third monitoring phase is about to be implemented at our 3 electric arc furnaces. Detectors will be installed at the filter dust transfer system to the dust storage bin. It is expected that an alarm will be given within minutes of the melting of a ^{137}Cs source. This will allow us to intervene as soon as possible, should an incident occur.

3. Our experience in handling radioactivity alarms

Since we commissioned the detectors for incoming scrap loads in December 1994 we got 54 alarms. The amount of scrap processed during this period of time is in excess of 10 million tons.

All these cases were level 1 alarms. All the radiating sources showed to be rather harmless:

- 25 cases of NORM deposit in some pieces of piping
  - a first series of 5 in 1995, the origin of which could be traced back to a coal mining operation in Germany)
  - a second series of 20 that haunted us during the end of 1998 and the beginning of 1999. We found a number of similar pieces of pipe scrap that had transited through the storage area at the fluvial port of Mertert. This stresses the importance to perform the controls as early as possible in the handling chain. While controls at unloading sites of ships and barges were technically very difficult in the past, promising new systems have come to the market. We are in the process of evaluating such systems for our unloading point at the Moselle-river.
- 1 steel plate with ^{60}Co contamination
- 1 phosphorescent dial from a vintage aircraft cockpit
- 1 lightning conductor

For most of the shipments that have been returned to the sender, no feedback about the findings has been available.

We have no experience yet in handling an in-plant alarm. I dearly hope we shall never have to. Let's keep the fingers crossed!

4. Conclusions

Disposal of radioactive material isolated following our monitoring activities tends to be a problem. Especially in a country that does not have any disposal site for radioactive waste. Even the rather harmless pipes with mineral deposits that we have collected during the last few months can only be disposed of following complicated procedures and at considerable cost. Effective international co-operation should help to resolve such problems.

Considering the high cost that a steel producer is expected to face, should an incident occur, insurance coverage would be welcome. Unfortunately such coverage is not readily available. Considering all the efforts that the steel industry is making in order to prevent severe incidents, it should be possible to convince insurance companies to provide coverage. Maybe there also international co-operation might be beneficial.

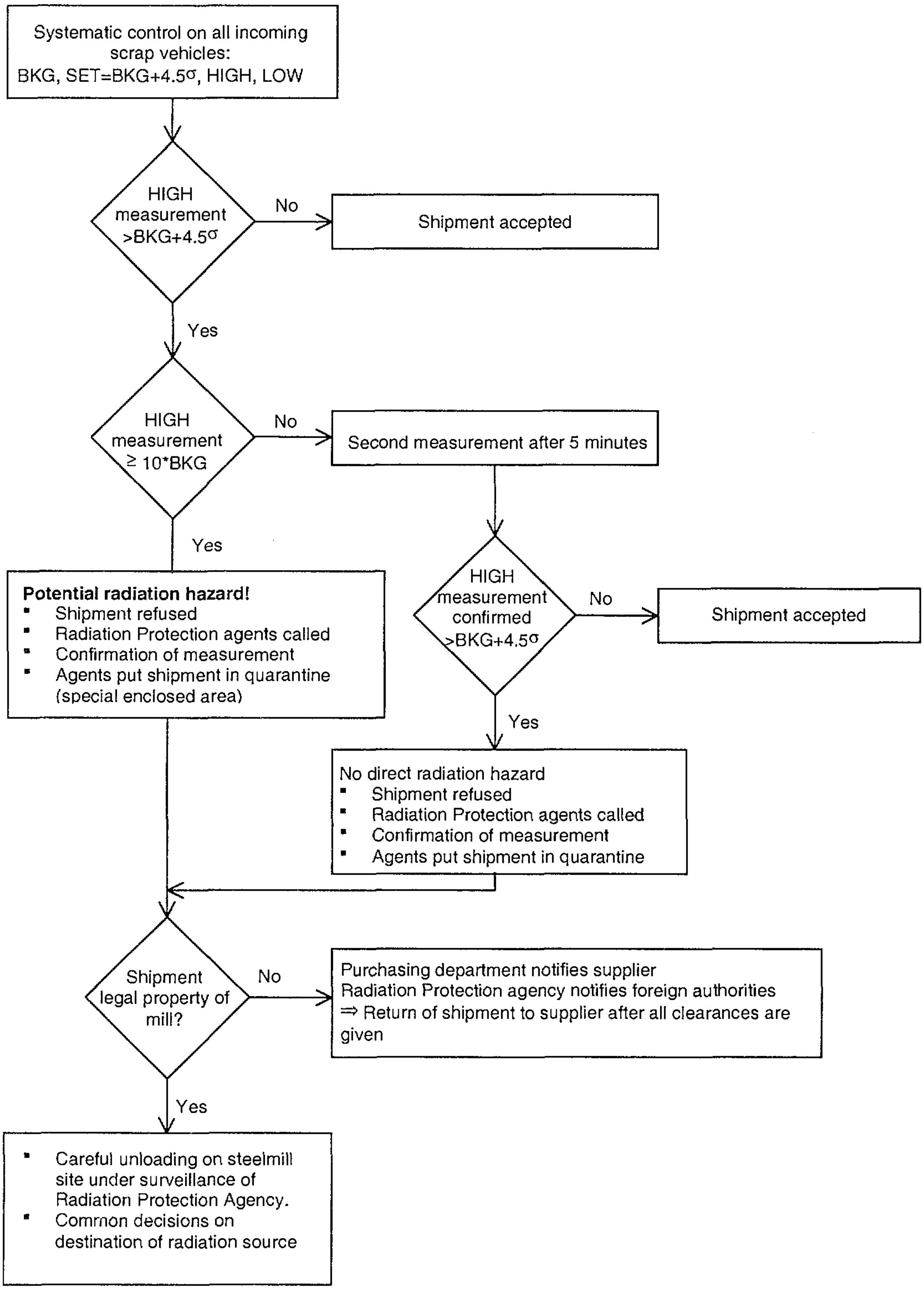

Figure 2: Decision chart for radioactivity control on incoming scrap shipments

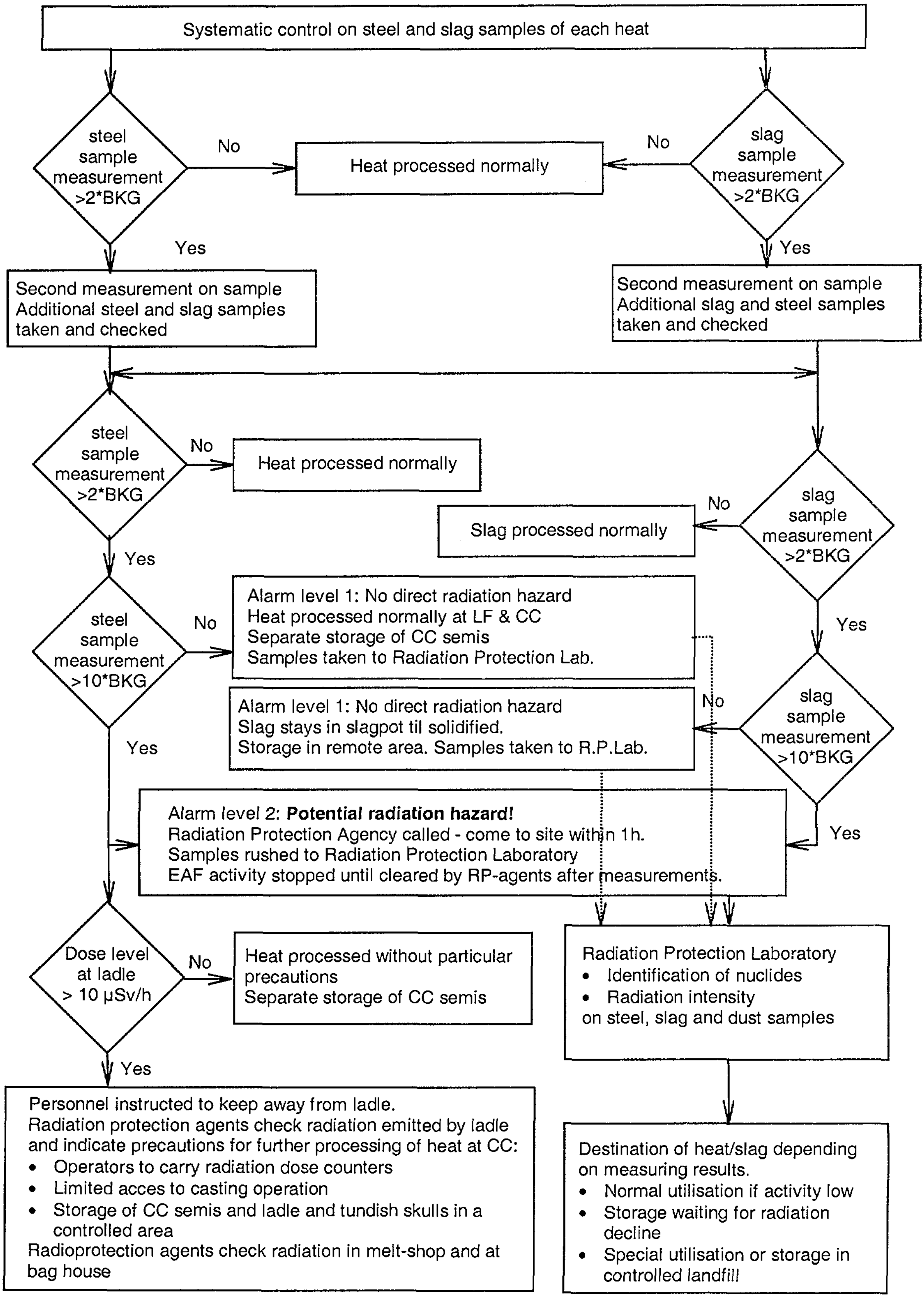

Figure 4: Decision chart for in-plant radioactivity controls

NEXT PAGE(S) left BLANK