Trends in air emission limits for world class mills

Mills face increasingly stringent regulations

By D. Bruce and T. van der Vooren

Abstract: Existing mills face ever-tightening air-emission regulations when undergoing a major modernization and new greenfield mills tend to match or even sometimes better the tightest regulations anywhere. Evidence of this trend is found in emission concentration data presented for levels typical of the 1980s, permits issued in the 1990s in several stringent jurisdictions surveyed, and a permit in principle received in 1998 for a proposed European mill. The bulk of the information is drawn from permits for 22 new and modernized mills pulp and paper mills in the U.S., Canada, Europe and the Nordic countries, which were obtained for technical background document, prepared for government in the mid-90s.

Governments use regulations to control air quality as part of their mandate to safeguard public health and the environment. In most stringent jurisdictions, the two main regulatory tools areas are:

- Establishing limits on emission sources;
- Setting standards for ambient air quality (AAQ), that is, for air at ground level.

Many of the source emission limits are industry-specific in most major pulp and paper-producing countries. Uniquely, in Germany, a very complete set of emission limits for a wide array of compounds has to be met by all industries including pulp and paper, leading to a need for great deal of source information. In less stringent jurisdictions, regulations that are really appropriate for pulp and paper may not exist.

Source limits often take the form of a maximum value for emission concentration, but sometimes are a mass emission rate or mass emission per tonne production or throughput for each contaminant. Most jurisdictions tie the limit value to an averaging period, since the concentration of most contaminants can be recorded by continuous emission monitoring equipment. Specifying the averaging time is critical for those parameters that are characterized by high variability ("spikes"), since a maximum-not-to-exceed limit can lead to disproportionate control costs. A better balance between possible environmental impacts and control costs is achieved if such emission limits are based on four-, 12- or 24-hour averages.

Ambient air quality standards tie maximum contaminant concentrations to averaging times, which may be 30 minutes, one hour, 24-hours, 30 days or 12 months.

To evaluate AAQ compliance of new or modified air emission sources, computerized air dispersion models combining topographical and meteorological information are used and allow the most cost effective emission controls and stack heights to be selected. In practice, AAQ compliance may be enforced by the installation of strategically placed ambient monitoring stations, with the telemetering of measurement data to the mill control room and the regulatory authority.

In some jurisdictions, air quality management has to address complex situations involving a multitude of sources within an air shed. In US non-attainment areas where the AAQ does not meet national standards, a mill expansion would face very demanding emission limits and possibly be required to undertake emission offsets at its expense. An offset is an emission reduction resulting from the installation of additional emission controls at another source that is more feasible to control.

GROWTH IN THE TYPES OF EMISSIONS REGULATED

In the 1970s, the focus of air emission regulatory efforts was directed at the common parameters of total particulate matter (PM), opacity, total reduced sulphur (TRS), sulphur dioxide (SO_2), chlorine (Cl_2) and chlorine dioxide (ClO_2). By the mid-1970s in the US and later in most other jurisdictions, however, the focus expanded to include nitrogen oxides (NO_x) and volatile organic compounds (VOC), mainly because of the concern regarding tropospheric, i.e., low-level ozone — a key component of smog and its impact on human health.

In the US, the original 1970 Clean Air Act first differentiated between these common parameters and a new class called hazardous air pollutants, or HAPs. The Clean Air Act Amendments of 1990 listed 189 HAPs. Difficulty was experienced with the health-based approach to identify HAPs, because one could not often determine a "no-effect" threshold concentration that would provide ample margin of safety to protect public health. Thus, a process involving a blend of health-effects science combined with a technology/economic feasibility-based approach was used, resulting in the Cluster Rules promulgated on

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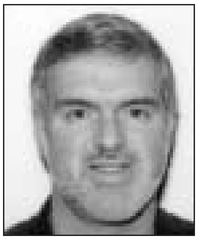

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TABLE I. Permit jurisdictions and types surveyed.

	Kraft Recovery	Smelt Vent	Lime Kiln	Sulphite mill	Power-Wood & Fossil	Power-Gas only
Canada	4	4	4	—	4	3
US	4	4	2	1	3	1
Sweden, Finland	11	6	9	—	7	—
France	1	—	1	1	3	—
Germany	—	—	—	—	—	—
Total	20	14	16	2	17	4

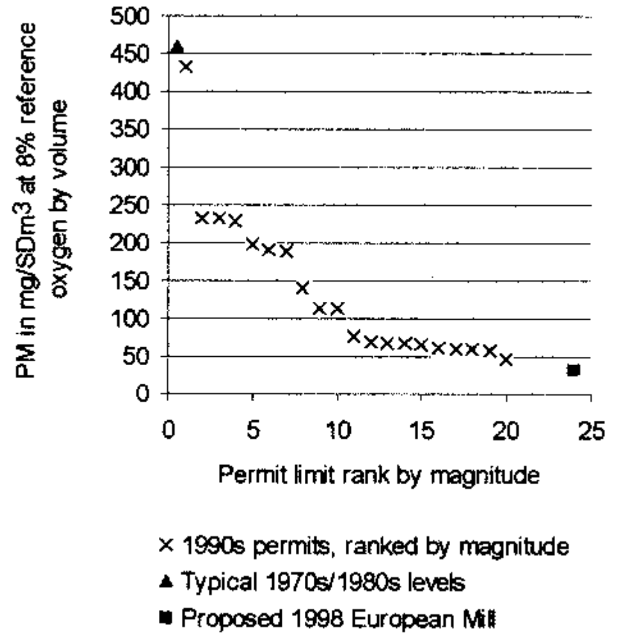

FIG. 1. Recovery boiler PM.

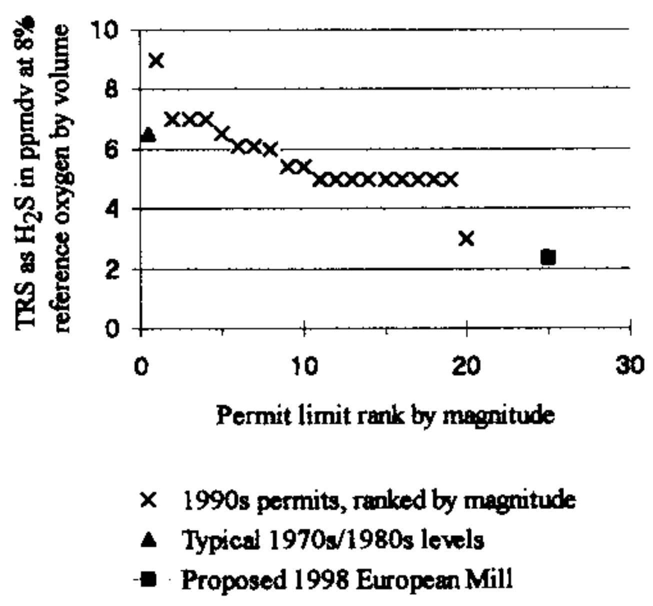

FIG. 2. Recovery boiler TRS.

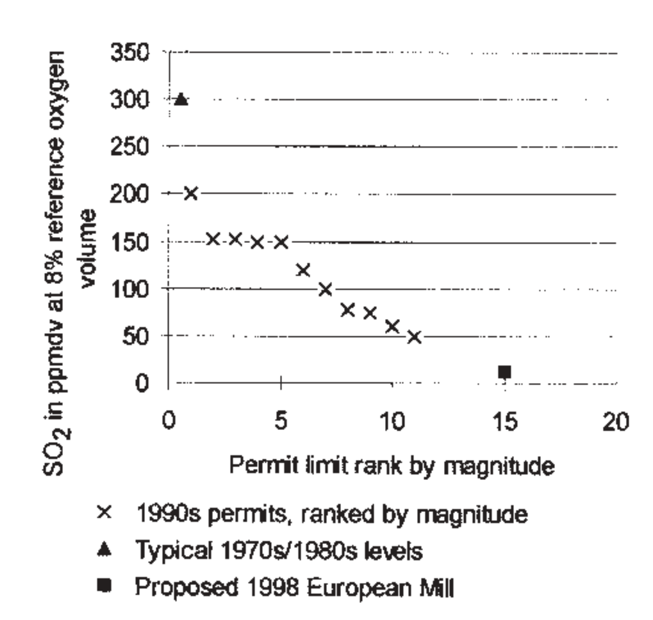

FIG. 3. Recovery boiler SO_2.

April 15, 1998. These rules define Maximum Achievable Control Technology (MACT) standards that must be met by existing and new pulp and paper mills. For the fibreline, the rules include the requirement for the advanced collection and incineration of both concentrated and dilute NCGs, while for the combustion sources, MACT standards take the form of good particulate control as a surrogate for metals, since much of the HAPs are found to be absorbed onto particulate.

In Canada, the federal government issued a requirement in 1994 for mandatory annual reporting of 176 contaminants listed in the National Pollutant Release Inventory (NPRI), to develop a comprehensive national database of the most important releases to air, water and land and transfers for recycling and disposal of toxic substances. The NPRI bears some resemblance to the Toxics Release Inventory of the US EPA. For the majority of substances the thresholds are the release of 10 t/a and concentrations of greater than 1%. For mercury and its compounds, the threshold is 5kg/a, and for polycyclic aromatic hydrocarbons 50kg/a. Hexachlorobenzene and dioxins/furan estimates are requested for specified types of activities and equipment, such as beehive burners, small combustors, wood preservation, kraft recovery boilers, salt contaminated wood waste fuel-fired power boilers, and power boilers as part of power-generation facilities generating in excess of 25 megawatt capacity.

As of 2002, the NPRI requires the reporting of 265 substances, of which 55 have been declared toxic under CEPA 1999. A significant change for the pulp and paper industry has been the addition of H_2S as a reportable substance, as it is a component of TRS.

FINE PARTICULATE AND OZONE

Rapid growth in the number of regulated emissions has matched advances in the science of health-effects determination. The upper respiratory tract has natural defences against the entry of relatively large particles when they are inhaled with air. Of greatest concern for human health, however, are the fine particulates. These are of such small size that they can penetrate deeply into the lungs, where a large fraction is deposited.

The sources and formation pathways of ground-level particulate below 2.5-micron diameter ($<PM_{2.5}$) are very different from those for larger particulate matter. Thus, $PM_{2.5}$ composition generally changes between the sack exit and point of deposition. The control of ground-level $PM_{2.5}$, therefore, has to focus not only on particulate leaving the stack, but also on both stack and atmospheric sources of SO_x, NO_x and VOC, since their chemical reactivity with the suspended material makes them fine particulate precursors.

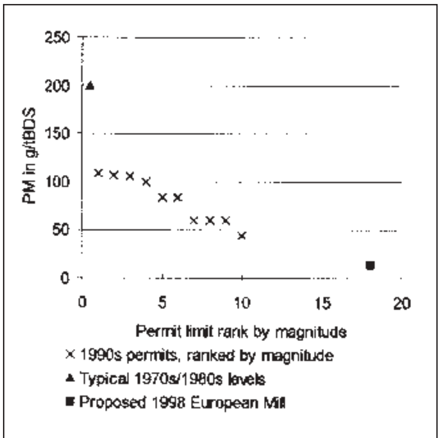

FIG. 4. Smelt dissolver PM.

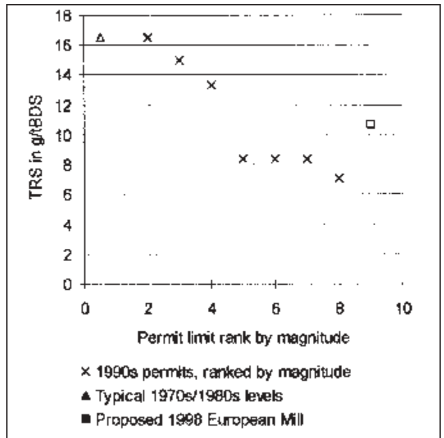

FIG. 5. Smelt dissolver TRS.

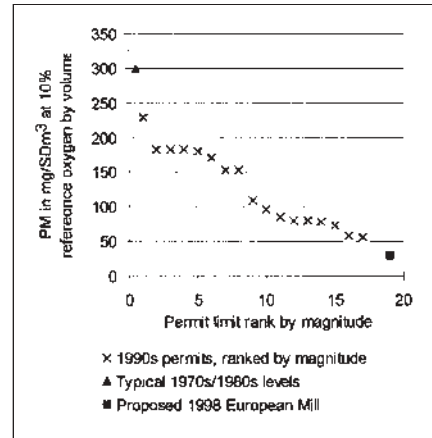

FIG. 6. Lime kiln PM.

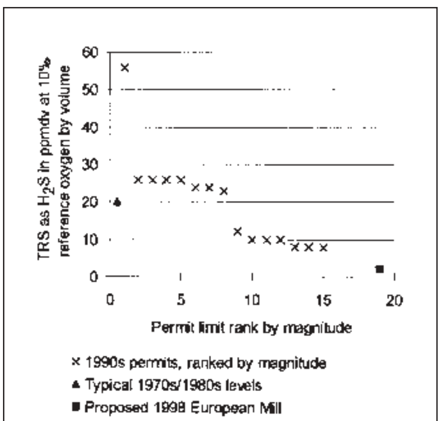

FIG. 7. Lime kiln TRS.

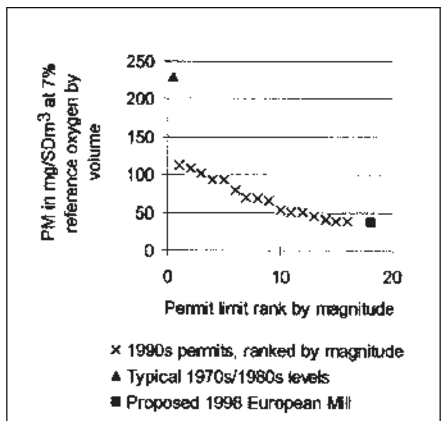

FIG. 8. Power boiler PM.

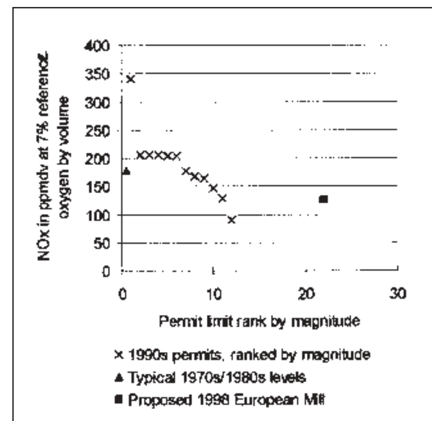

FIG. 9. Power boiler NO_x.

In June 2000, the Canadian Council of Ministers of the Environment, with the exception of Quebec, endorsed Canada-wide Standards (CWS) for $PM_{2.5}$ and ozone to be achieved by the year 2010. These are:

- $PM_{2.5}$: 30 micrograms/m^3, 24-hour averaging time, with achievement to be based on the 98th percentile ambient measurement annually, averaged over three consecutive years.
- Ozone: 65 parts per billion, eight-hour averaging time, with achievement to be based on the fourth-highest measurement annually, averaged over three consecutive years.

$PM_{2.5}$ and ground-level ozone are two of the six substances selected as priorities for development of CWS. Other substances being addressed through the CWS process include benzene, mercury, dioxins and furans, and petroleum hydrocarbons in soil.

SURVEY OF SELECTED AIR EMISSION PERMITS

Comprehensive evaluation of air-emission regulations among different jurisdictions to compare differences and their effect on mill design would be a time consuming exercise. For this paper a more pragmatic approach was used, involving air permit limit values, since they are the final product of the regulatory review process and a measure of compliance difficulty,

Most of the permits date from the 1990 to 1995, a period of heavy investment in the industry. The permits are summarised in a technical background document prepared for the federal and BC departments of the environment in 1995 [1].

The numbers of sources and the provenance of the permits (73 sources from 17 kraft mills, two sulphite mills and one mechanical pulp mill) are show Table I. The permits are for new greenfield mills or for mills that have undergone extensive modernization, and therefore undergone a permit renew process.

The permit concentration limits for the common parameters are presented in graphical form in Figs. 1 to 8. The figures are limited to kraft mill permits, as insufficient permits were obtained to establish trends for other types of mills. For each emission parameter, the data is ranked by magnitude from the highest to the lowest value to highlight the range of the limit values found. This means that for a given permit, the rank for one parameter may differ from that for another parameter. Note as well that the ranking does not necessarily reflect the year of the permit, though there is a tendency for more recent permits to be more restrictive.

Shown for reference near the ordinate is the approximate emission concentration typical of mills of the late 1970s to mid-1980s, and at the right-hand side of the figure, the very stringent emission limit for a kraft pulp mill that received permit approval in Germany in 1998.

In Figure 1, particulate matter from recovery boilers has recently dropped from 450 mg/SDm^3 to about 60mg/SDm^3, with the proposed German mill permitted at even lower numbers. This reflects the much higher reliability and efficiency of electrostatic precipitators that have been installed in recent years. The TRS emission limits shown in Fig. 2 have actually dropped much more since the 1980s than shown, since the data is for only low odour-type recovery boilers. Levels in some old direct contact-type recovery boilers can be an order of magnitude higher than what the best low odour-type units emit today. It is also noteworthy that the particulate data for the recovery and the lime kiln for the German mill are very similar to the recent MACT II limits for recovery boiler, smelt dissolver, and lime kiln sources for new mills in the US.

Sulphur dioxide emissions from recovery boilers have been regulated to significantly lower levels as well, Fig. 3. These levels have dropped by a factor of six over the last two decades. This has been achieved by the much preferred use of in-process rather add-on controls: these include the introduction of high solids black liquor firing, much improved recovery boiler process control, and replacement of direct contact evaporator recovery boilers by the low odour type.

For example, PM from lime kilns shown Fig. 6 and from wood-fired power boilers in Fig. 8, have also seen reductions in permitted values of nearly an order of magnitude over the last 20 years. This has been accomplished primarily by the shift from scrubbers and mechanical collectors to more expensive, but more efficient, electrostatic precipitators.

Résumé: Les règlements en matière d'émissions atmosphériques sont de plus en plus exigeants pour les usines existantes lorsqu'elles tentent de se moderniser, et les nouvelles implantations, peu importe où elles ont lieu, ont tendance à se conformer aux règlements les plus stricts, et même à les dépasser. Cette tendance se manifeste dans les données sur la teneur à l'émission présentées pour des niveaux typiques des années 80, des permis accordés dans les années 90 dans plusieurs juridictions strictes, et un permis de principe reçu en 1998 dans le cadre d'une proposition pour une usine européenne.

Reference: BRUCE, D., VAN DER VOOREN, T. Trends in air emission limits for world class mills. *Pulp & Paper Canada* 104 (7): T190-193 (July 2003). Paper presented at the 86th Annual Meeting in Montreal, QC, in January 2000. Not to be reproduced without permission of PAPTAC. Manuscript received November 17, 1999. Revised manuscript approved for publication by the Review Panel September 5, 2002.

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CONCLUSIONS

The results illustrate the very dramatic improvements in air emission control that has occurred for many kraft mill sources, the main emission sources in the Canadian pulp and paper industry, over the last two decades.

It is important t to recognize that this ranking is only an approximate indication of increased compliance difficulty, because averaging times vary among permits, there may be daily caps on mass emission rates, and special conditions may apply to periods of process upset and start-up/shutdown operations that have not been taken into account in this analysis. For instance, limits on permitted emission concentrations are defined in Germany and Austria in terms of a 24-hour averages. A source must not only comply with the Limit Value, but must also not exceed twice the Limit Value in any 30-minute average. In addition, 97% of all 30-minute averages must be below 120% of the Limit Value. As the Limit Value is the number that is embedded in the permit, the regulatory regime can be perceived as being more stringent than, say, a North American mill, if limits are based on less than 24-hour averaging periods — and even more so if based on not-to-exceed limits.

Also, there is a tendency for Nordic and European TRS standards to consider only the H_2S component. To allow comparison with TRS permit limits elsewhere, stream compositions have had to be assumed.

It is not yet clear where the trend, other than generally moving downward, will lead to over the next five to ten years. For particulate, the regulatory steps initiated in the US and Canada only represent, perhaps, the early stages of a long and technically challenging implementation process that will take many years to effectively put in place. The steps include developing monitoring technologies and protocols, determining the pathways of $PM_{2.5}$ formation from stack to ground, and establishing control strategies.

Successful regulation will continue to be driven by a blend of advances in health-effects science and a pragmatism that recognizes the limits of what is technically and operationally feasible at a reasonable cost.

LITERATURE

1. H.A. SIMONS LTD. Technical Background Document on Air Emission Control in the Pulp and Paper Industry for Environment Canada and the BC Ministry of Environment, Lands, and Parks. Vancouver: H.A. Simons Ltd (1995).