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Swedish Researcher Attacks SBS Head On

We may not know exactly what causes SBS symptom complaint rates to rise in problem buildings; however, perhaps we can still reduce them with practical, cost-effective methods. This is the notion put forward by researcher David P. Wyon of the Swedish Building Research Institute. Wyon's report of a study he conducted in a southern Swedish hospital appeared in *Environmental Technology* earlier this year. (See the reference at the end of this article.) The report is quite convincing. Titled "Sick Buildings and the Experimental Approach," the report is one of the most interesting SBS studies we've seen in some time.

Background

More than 25% of over 1,000 workers at Malmö General Hospital had registered complaints of SBS symptoms through Sweden's formal industrial injury complaint registration procedure. Investigators thoroughly inspected the building and found the ventilation system operating according to specifications, filters changed on schedule, clean ducts, and all rooms equipped and furnished according to the design. But the complaints led to a press campaign and the surgical wing was labeled a "sick building."

All of the complaints were of SBS-type symptoms. Yet the hospital was designed and operated to "a very high standard," and Wyon says that measuring every available physical parameter was unlikely to identify the causative factors.

Hospital staff felt that humidifying and ionizing the air would alleviate their symptoms. Wyon believed in advance that humidification might help but felt that the risk of causing problems was as great as the likelihood of alleviating them. He knew of other studies where improperly operated humidification systems were associated with elevated SBS complaint rates. While agreeing that humidification might reduce complaints of dry air, he suggested that a slight temperature reduction might have the same effect. (See ***IAB*** Vol. 2, No. 1, p. 4.)Besides, Wyon says, humidification consumes considerable energy and is expensive to install and run.

According to Wyon, ionization is a well-established technique in southern and eastern Europe. However, there are no published studies of *positive* effects on man except in asthma therapy, to treat burns, and to reduce airborne infection. Advocates of negative air ionization will disagree; they feel its benefits are significant. All of the positive effects, Wyon says, could be adequately explained by the rapid deposition of particles on oppositely charged surfaces: the ionization simply removes particles from the air. Unless respirable dust and certain types of electrostatic fields are found near subjects, more speculative explanations of the effective ionization mechanism are unnecessary, according to Wyon.

The Experiments

Authorities set up well-controlled field trials of how humidification, ionization, and seven other environmental measures affected SBS complaints. The object was to evaluate the measures against SBS symptom intensity and frequency. The results, described later, were surprising even to Wyon.

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P.O. Box 8446, Santa Cruz, CA 95061-8446 (408) 426-6624

There were four overall goals for the studies:

- To determine if available objective measures of SBS symptom intensity would co-vary with subjective symptoms.
- To discriminate between effects caused by expectation and effects caused by actual impacts on the physical environment.
- To exclude effects from external factors such as weather, epidemics, season, public debate, or press campaigns.
- To find simple ways to identify effective mitigation measures in complaint-ridden buildings.

Wyon emphasizes that these goals were stated at the outset as being more important than discovering the underlying causes or identifying any particular "air pollutants presumed to be causing the problems." He says that 20 years of worldwide research directed toward identifying specific SBS causes had failed.

The researchers tried the nine different mitigation strategies for periods of three weeks each during the heating seasons of 1988-89 and 1989-90. They evaluated the effects of the measures in terms of the impacts on SBS symptom intensity and frequency of occurrence. They used well-defined mitigation procedures, placebos, and reference wards to evaluate the impact of the mitigation methods and to study other research questions of interest. The nine experimental conditions are described in Table 1.

Condition	Period	Description
1. Low air flow	11/21/88-12/11/88	70% of normal airflow
Reference	Same weeks	Normal airflow
2. High air flow	1/30/88-2/19/89	140% of normal air flow
Reference	Same weeks	Normal airflow
3. Air cleaners	2/20/89-3/12/89	Free-standing air cleaners
Reference	Same weeks	No air cleaners
Placebo	Same weeks	Simulated air cleaners
4. New cleaning routines	1/9/89-1/29/89	Reduced use of chemicals
Reference	Same weeks	Normal cleaning
5. Low temps	1/9/89-1/29/89	1.5°C lower room T
6. Anti-static measures	2/27/89-3/19/89	Clothing, surfaces treated
Reference	Same weeks	Normal clothing, etc.
Placebo	Same weeks	Simulated measures
7. Reduced glare	1/15/90-2/4/90	Modified light fittings
Reference	Same weeks	Normal lighting
8. Air ionization	1/22/90-2/11/90	Ionizers in operation
Reference	Same weeks	No ionizers installed
Placebo	Same weeks	Ionizers disabled
9. Humidification	2/12/90 - 3/4/90	Steam humid. +15%RH
Reference	Same weeks	No humidification

Table 1 - Experimental Conditions, Timing, and Description.

Co-variability of Symptoms and Signs

The researchers also tried to find out whether subjective symptom intensities varied together with objective measures of SBS symptoms. For example, the investigators evaluated dryness of mouth by measuring saliva quantity and the time taken to swallow a vitamin tablet presented unexpectedly. They measured dry lips by observing lip moisture and by the subjects' reported use of lip salve during the same day. They measured break-up time (BUT) for tear film on the subjects' eyes to determine the association with eye discomfort. (BUT indicates physical changes in the tear film that are plausible precursors or concomitants of eye irritation.)

They compared reported aspirin use with reported headaches and feelings of "heaviness in the head." Wyon comments that the expression "heavy in the head" is "a common Swedish expression distinguishable from a true headache." [When asked why the Danes seem to report "heavy headedness" in their SBS studies whereas Europeans from more southerly countries do not, Danish researcher Lars Mølhave replied: "It's from our Viking helmets."]

Results

Overall, the researchers found humidification and ionization to be most effective of the eight experimental conditions evaluated in terms of their measurable effect on SBS. (Air cleaning was not evaluated because the experimental conditions did not produce measurable differences in airborne particle concentrations. The devices were deemed too noisy when operated as intended, so the flows were reduced to produce less noise. The result was that no real air cleaning was obtained due to the very low air flow rates.) Wyon stresses that the results were unexpected and he urges caution in interpreting them. He believes the findings must be confirmed in longer follow-up studies.

The changes in SBS symptom intensity and frequency resulting from the nine environmental interventions are shown in Table 2.

Negative Ion Generators Show Clear, Positive Effects

Wyon found a beneficial effect from using negative ion generators plus a small, positively charged external panel maintained at a nominal 8,000 volts. Using negative ionization together with positively charged anodes had a

	Condition	Results
1.	Low air flow Reference	Not significant
2.	High air flow Reference	Not significant
3.	Air cleaners	Not significant; experiment not run as planned; only a negligible difference between experimental and reference wards.
	Reference Placebo	
4.	New cleaning routines Reference	Not significant
5.	Low temperatures	Positive (P<0.02)
6.	Anti-static measures Reference Placebo	Not significant
7.	Reduced glare Reference	Positive (P<0.02)
8.	Air ionization Reference Placebo	Beneficial (P<0.02)
9.	Humidification Reference	Reduced symptom severity (P<0.01)

Table 2 - Summary Results from Experimental Conditions.

"highly significant and beneficial effect on SBS-symptoms ($p<0.002$) in comparison with the placebo condition.... The effects were numerous, large, and statistically significant, and no negative effects of ionization were observed." Concurrently measured SBS symptoms in reference wards "...did not differ from those measured at other times in other reference wards."

The measured negative ion concentration was 26,000/cm^3 in the experimental ward and 60/cm^3 in the reference and placebo wards. The corresponding positive ion concentrations were 0/cm^3 and 160/cm^3 respectively. We believe it important to stress that the negative ion generators were used in conjunction with positively charged anodes (8kV), not alone as is often the case. This means that the charged particles created by the negative ion generators were removed by the anodes, not simply allowed to "plate out" on any available surface.

Figure 1 shows the responses to the ionization compared to the placebo condition. Clearly the ionization had a positive effect on nearly all symptoms. In 12 experimental and placebo wards with a total of 339 subjects, using the ionization system was positively associated with reduced SBS symptom rates. (The distance of each data point above the diagonal shows the magnitude of the positive effect in the ionization situation compared to the placebo condition.)

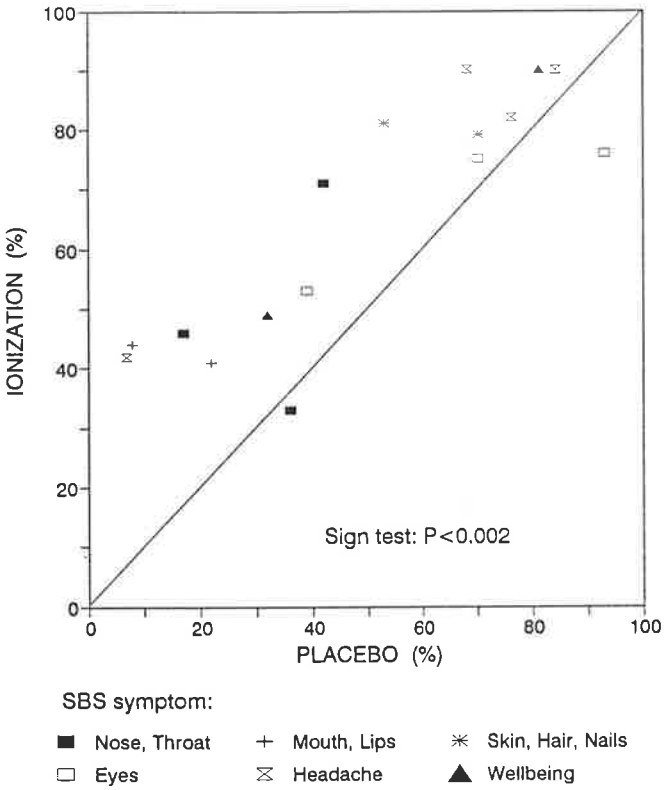

Figure 1 - Percent Responding Positively to Ionization.

To visually confirm the particle removal action of the ionization system, researchers placed filter paper on the positively charged panels. They observed that these rapidly became discolored although changed frequently. Investigators and building operators can use this method as a convenient, qualitative examination of particle loading in a space when using ionization/positive charge collectors.

Increased Humidity Decreases Symptoms

The experiments were all done during the winter; it should be no surprise that increasing humidity from 25% to 40% reduced the severity of symptoms ($p<0.001$). However, Wyon points out, not all of the observed effects were positive; "...the staff reported significantly more subjectively experienced 'stress.'" Figure 2 shows the results of the humidification experiment (40% RH compared with 25% RH in the reference wards).

Associations Between Objective and Subjective Measures

To determine the relationship between subjectively reported symptoms and objective signs, researchers observed both experimental and reference wards. They examined a total of 222 subjects in the eight reference wards. Table 3 shows the results.

The researchers examined 339 subjects in the 12 experimental and placebo wards to determine whether

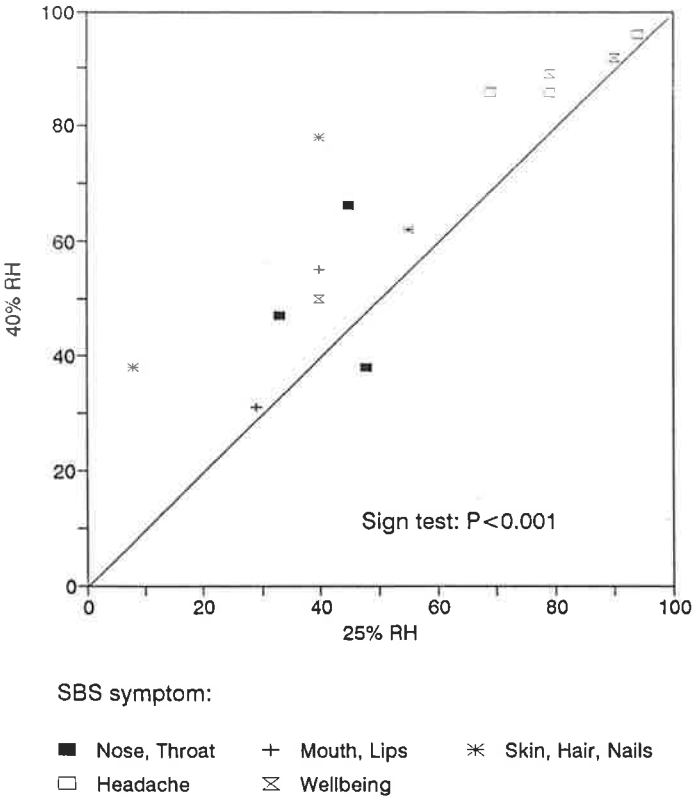

Figure 2 - Percent Responding Positively to Humidification.

SBS Symptom	Objective Evidence in Reference and Placebo Wards
Dryness of the mouth	Reduced saliva quantity (p<0.02)
	More time to swallow vitamin pill (p<0.001)
Dry lips	Observed dry lips (p<0.001)
	Reported use of lip salve (p<0.01)
Eye discomfort	Reduced tear film BUT* (p<0.05)
Headache	More reported use of aspirin (p<0.001)
Heavy headedness	More reported use of aspirin (p<0.05)

* Break-up Time

Table 3 - Relationship Between SBS Symptoms and Objective Signs in Experimental and Reference Wards (n=222).

objective signs accompanied significant changes in SBS symptom rates. They found that objective changes had also taken place as shown in Table 4. Wyon concluded that the research had shown "objective measures confirmed subjective SBS symptoms, both between people

Experimental Condition	SBS Symptom Effect	Objective Evidence in Same Population
Ionization	Alleviated dry throat (p<0.05)	Reported use of throat pastilles that day (p<0.05)
Ionization	Reduced dry lips (p<0.001)	Observed dry lips (p<0.10)
Ionization	Reduced dry skin (p<0.001)	Observed dry skin on fingers (p<0.10)
Ionization	Reduced brittle nails (p<0.02)	Observed cracked or broken nails (p<0.05)
Ionization	Reduced dry eyes (p<0.02)	Increased inter-blink interval (p<0.001)
Increased humidity	Reduced dry skin (p<0.01)	Observed dry skin on fingers (p<0.02)

Table 4 - Changes in Objective Evidence of Symptoms Corresponding to Experimental Conditions With Positive Effects on Reported SBS Symptoms in Experimental and Placebo Wards (n=339).

under reference conditions and in response to environmental change."

Wyon's Hypotheses on Mechanisms

After appropriate disclaimers regarding the dangers of inferring causality from statistical associations, Wyon put forward some hypotheses regarding the underlying mechanisms for the observed positive effects on SBS symptoms:

- The ionization reduced the density of airborne respirable particles (and the measurements showed that this was the case).
- The lower temperature and increased relative humidity directly affected the moisture balance of the mucous membranes and, therefore, had a positive effect on mucous membrane "flow rates and their ability to deal with airborne particles."

The reduced glare conditions caused "red eyes" less often (as researchers observed with staff).

Again, Wyon stresses that "these are only hypotheses to explain the observed empirical effects of the technical measures on SBS."

IAB Comments

According to Wyon, determining how to mitigate IAQ problems presents substantial ethical and economic challenges. Wyon has shown that an experimental approach can be practical and meet ethical criteria related to experiments involving human subjects. He believes the Malmö approach addressed these ethical questions in ways many other studies fail to consider.

Wyon concluded that field experiments studying the effects of various technical measures on SBS can provide a "cost-effective basis for investment decisions, whether or not the underlying cause of the problem is understood." This, of course, is anathema to many researchers who believe that it's not enough to know that a method works: one has to know why it works. Scientific tradition limits the acceptability of such practical approaches for many in the indoor air community. However, for building owners, managers, tenants, or designers, what works is what counts.

Reference:

David P. Wyon, 1992. "Sick Buildings and the Experimental Approach." *Environmental Technology,* vol. 13, pp. 313-322.

For more information:

David P. Wyon, National Swedish Institute for Building Research, Box 785, 801 29 Gavle, Sweden.

Ventilation

Europeans Publish New Ventilation Guideline

The Commission of the European Communities (CEC) has published a ventilation guideline that establishes a new approach to determining ventilation rates. The approach is two-fold; first, that there should be no more than a negligible health risk for occupants breathing indoor air. Second, that occupants should perceive the air as "fresh and pleasant rather than stale, stuffy, and irritating." It says that "the quality of the indoor air may be expressed as the extent to which human requirements are met. The air quality is [considered] high if few people are dissatisfied and there is a negligible health risk."

The report presents more explicit guidance on indoor air VOC concentrations than has previously been adopted by any authoritative body. The VOC guidelines, if followed, will severely limit pollutant source strengths. The guidelines also allow the designer to specify air quality based on three distinct categories of acceptability: 10%, 20%, and 30% or less of occupants being dissatisfied. Determining acceptability is based on the predicted percent of occupants that will be dissatisfied with the perceived air quality using subjective assessment of the odor, comfort, and irritation aspects of the air.

The document, *Guidelines for Ventilation Requirements in Buildings,* reflects a voluntary consensus among representatives from the CEC member nations. It is a set of recommendations rather than a regulatory document. Its provisions are extremely important; however, they are not free from controversy. Ultimately, each member nation independently determines whether to adopt the *Guidelines'* provisions. However, the publication of the *Guidelines* report is likely to lead to the adoption of at least some of its significant recommendations.

Purpose

The Purpose statement says: "This document recommends the ventilation required to obtain a desired indoor air quality in a space. Selection of low-polluting materials and products in buildings is recommended." The scope statement excludes thermal comfort parameters but references ISO Standard 7730, which is essentially the same set of thermal comfort requirements as ASHRAE Standard 55-1981.

Individuals involved in the *Guidelines'* development and adoption told ***IAB*** that implementing the detailed requirements requires data that are not yet generally available. However, they believe the document will stimulate developing the necessary data. These data include chemical emissions rates from building materials and subjective evaluations of emissions and indoor air.

Pollutant Guidelines

An oft-repeated criticism of ASHRAE Standard 62, *Ventilation for Acceptable Indoor Air Quality*, is that it provides little practical guidance on indoor air pollutant concentrations even though it mandates maintaining IAQ within "acceptable" limits. It provides threshold limit values (TLVs) for occupational exposures and guidance information on scores of contaminants in an appendix. Yet the appendix advises that the TLVs are too high for non-industrial indoor air. It suggests that 1/10 of the TLVs be used as guideline values, but that these values might not protect sensitive individuals. In sum, the ASHRAE standard backs away from establishing exposure guideline values.