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Simulating Wall and Corner Fire Tests on Wood Products with the OSU Room Fire Model

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ABSTRACT: This work demonstrates the complexity of modeling wall and corner fires in a compartment. The model chosen for this purpose is the Ohio State University (OSU) room fire model. This model was designed to simulate fire growth on walls in a compartment and therefore lends itself to direct comparison with standard room test results. The model input were bench-scale data obtained from the ASTM Test Method for Heat and Visible Smoke Release Rates for Materials and Products (E 906). Six wood materials were tested in the bench-scale test and also in an ASTM room fire test (proposed method). The simulations from the OSU model were compared with the database of 26 room tests representing a range of conditions. We treated the model as a black box and only varied the input data. The criteria used for comparison were heat release rate. radiative heat flux to the floor. and upper layer temperature. The agreement between model predictions and experiments varied. We conclude that the OSU model in its present state of development is not able to track fire growth in scenarios of the burner source against the back wall. The accuracy of the bench-scale data and methods to reduce the input data play a very important role in the simulation results. This work also raises many important issues such as the need for clear documentation of the modeling process and the definition of criteria for determining good agreement between the model simulation and experimental results.

KEYWORDS: fire models, validation, predictive capability

Background

Fire safety is a very important aspect of engineering and architectural design of structures. The fire performance of a material and its intended use can make a difference in the acceptability of the material. The traditional approach to fire safety has been based on testing of materials and assemblies in contrived scenarios. The test results have been used as a basis for codes and regulation purposes with some success. However, this approach is not useful for risk and hazard analysis which requires much more flexibility. Experience shows that many factors other than the ones being tested must be taken into account to assess true fire performance. Consequently. the modern approach to fire safety design and engineering tries to take into account as many factors as possible. The primary factors are related to the materials themselves: ignitability. heat and smoke release. flame travel rate. and thermophysical properties. Secondary factors are related to the application of the ma-

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terial, its intended use, and configuration and geometry of the surrounding boundaries, as well as methods of detecting and suppressing fires.

Because of the complexity of fire safety problems, efforts are being made to understand the fire and material reaction to fire. A great deal of research has been done in the last two decades in this direction. With the advent of computers, numerous efforts have been made to utilize the knowledge of fire physics in modeling fire development, smoke and heat flow, safe egress time, detection and suppression, and structural integrity. Of critical importance is the modeling of fire development or fire growth. The rate of fire growth determines how much time is available for egress before the conditions become untenable. The significance of fire growth has made efforts to model fire growth a major thrust of the fire research community.

A number of fire growth models have been designed to perform different calculations. Some are designed to predict burning of contents such as furniture and mattresses (HARVARD. FIRST) [*1, 2*]. Another model is designed to calculate the movement of smoke and toxic gases from the compartment of fire origin through a building (FAST) [*3*]. One package of software named HAZARD I [*4*] has been built around FAST and integrates other models such as EXITT (evacuation), DETACT (detector activation). and TENAB (tenability limits) to calculate hazard to occupants. Of the models that calculate fire growth on wall surfaces, the oldest is the OSU room fire model [*5, 6*]. Although this model has been used with some success, there is little acceptance of its validity as a result of its empirical nature and numerous assumptions.

Since wall and ceiling lining materials are regulated by codes, they have to be tested. The traditional test for wall and ceiling materials is the ASTM Test Method for Surface Burning Characteristics (E 84) [*7*]. There is a movement in the international community to evaluate lining materials in the room fire test (ISO and ASTM proposed standard) [*8, 9*]. Driven by the need to understand fire growth on walls, the need to model room fire scenarios has become the subject of both academic and practical interest.

The USDA Forest Service, Forest Products Laboratory (FPL) and the National Forest Products Association (NFPA) conducted a joint study to investigate and model room fires. Their approach was to establish bench-scale data of ignitability, heat release. and flame spread of a range of wood products, and use them as input data to predict full-scale fires. The predictions were then compared with full-scale tests conducted in the room fire facility at FPL. which was instrumented to yield data for comparison and validation.

The results of the bench-scale and full-scale tests were of interest to the fire research and testing community and have been published [*10, 11*]. The major part of the modeling effort that required further work was supported by the USDA Cooperative State Research Service under grant 90-37291-5752. The scope of this grant study includes two items:

1. Evaluate the model developed by the Ohio State University (OSU) in its latest version using data from the FPL/NFPA study.
2. Develop a model (a modified OSU room fire model named MOSURF) using data from the state-of-the-art bench-scale equipment and more rigorous fire physics.

This report covers Item 1 in which the latest public domain version of the OSU model in FORTRAN named ROOM992 is evaluated: this version is maintained by the Weyerhaeuser Company (Weyco).

OSU Model

The OSU model was initiated by Edwin Smith of the OSU in the early 1970s. The excellent concept of using bench-scale data to predict full-scale scenarios was born around that time.

Smith also invented the OSU heat release apparatus, which became the ASTM Test Method for Heat and Visible Smoke Release Rates for Materials and Products (E 906) [*12*]. Heat and smoke release data obtained from the OSU heat release apparatus plus some other data on ignitability and flame spread are the main input to the model. The OSU model utilizes the "modular" approach, which divides the compartment into control volumes or zones.

To provide a theoretical basis for modeling wall fires, several graduate students of Smith performed excellent work on wall flame structures in regard to flame heat transfer. One example of such work is the research by Yam [*13*]. A number of graduate students later worked on various aspects and modifications of the model [*14-17*]. Smith and Satija provided the first and also the most descriptive document of the model and its algorithms [*6*]. This document outlined the basic structure of the model, input and output, and major equations. The original methods to predict ignition, rate of flame propagation, heat and smoke release rates. and heat and mass balances around control volumes still remain in the current OSU version.

The concepts that are contained in the OSU model. some of which are unique to the OSU model, are the "flux time product" concept for predicting ignition, the incremental volume of the plume (IVP). and the division of the compartment volume to two layers (upper and lower layer) and subdivision of the upper layer into upper and lower zones. The user of the model is advised to review the literature by Smith and co-workers to be familiar with these concepts.

The input data to the OSU model are in the form of both an input file and subroutines within the main program. The input file contains information about the materials' thermophysical properties, location of the fire source, compartment and vent dimensions. and some user-specified coefficients for entrainment and mass flow calculations. The user can select the location of the fire source to be in the corner of two walls. center of one wall. or center of the room.

Three subroutines are used to input data: heat and smoke release. flame travel rate. and fire source. named RR, FTR, and QSUB, respectively. The subroutines RR and FTR are based on experimental data from the OSU heat release apparatus.

For charring materials such as wood, Smith showed that heat release rate was a function of heat flux and the burning history expressed as total heat release up to that point [*18*]. Therefore. it is possible to predict heat release rate from a burning segment of the wall material using a set of equations derived from heat release rate data. This set of equations results from a process called "anamorphasizing" by Smith [*5*]. Typically, three heat release rate curves are obtained from testing the material at three heat flux levels. The heat release rate data are plotted against total (cumulative) heat release. The total heat release (abscissa) is first scaled so that the three curves have similar shapes. One curve is used as a reference curve that can be represented by a polynomial function. The other curves are scaled based on this reference curve. The process of anamorphasizing heat release data is rather unique and is used rarely for data reduction (other than by Smith).

Flame travel rate data are obtained in the heat release rate tests by measuring the time required for a spreading flame from an impinging pilot over a lateral distance of 20 mm (0.79 in.). Flame spread data as a function of heat flux are used to predict lateral flame spread on wall surfaces from the flame.

Previous Experimental Verification of Model

Throughout the history of the OSU model development, several experimental programs have been conducted to verify model accuracy. The document by Smith and Satija [*6*] contains some comparisons of upper layer temperature, smoke release, heat output of several tests run at the OSU large-scale test facility, and tests by Upjohn Company with the model calculations. Sauer's thesis contains a more complete description of the tests [*16*]. The agreement between model and experimental data was impressive. The set of full-scale experiments include five tests: Upjohn tests 2017 and 2021 and OSU tests 721, 723, and 727. All of these tests were done in a compartment 2.4 by 2.4 by 3.6 m (8 by 8 by 12 ft) with door dimensions of 2.1 by 0.7 m (7 by 2.33 ft). For the Upjohn tests, the wall materials were a plywood and a rigid isocyanurate foam. The corner gas burner simulated a 9-kg (20-lb) wood crib. The OSU tests had gypsum wallboard. with either one or two reference chairs used as ignition source, and one test with polyvinyl chloride-acrylonitrile butadiene styrene (PVC-ABS) as wall/ceiling lining with one corner seat as the ignition source.

Green's thesis on radiation heat transfer [*17*] mentioned three tests run at the Owens-Corning Fiberglass Life Safety Laboratory. Basically. these were corner room tests with a methane burner set at 65 kW. If flashover did not occur, the burner power was increased to 200 kW at 10 min. Thin luaun plywood [7 mm (0.27 in.)] was used in the first two tests and 19-mm (0.74in.) exterior grade plywood was used in the third test. Ceiling and floor material was calcium silicate board (marinite). Radiation fluxes at the door and a selected location on the wall were compared with model calculation. Agreement was quite reasonable.

In summary. a certain degree of model verification has been done with encouraging results. although minimum detail was given to documentation of input variables. However. there remain many questions about model validation or verification:

1. What constitutes validation?
2. What challenges must a model meet before it is considered validated?
3. What types of documentation are needed to show validation?

At present, the fire research and fire safety engineering community is trying to set standards for model validation. One available document is the ASTM Standard Guide for Evaluating the Predictive Capability of Fire Models (E 1355) [*19*]. Note that the terminology "predictive capability" is used instead of "validation." Although it is admitted in the document that it is impossible to validate models *per se,* some ideas are nevertheless worthwhile pursuing. One is independent assessment by "impartial" users much like the way products are evaluated by consumer guides. Obviously, there are other questions concerning the motives and qualifications of the evaluators. In lack of an answer to these questions. any approach to shed some light on validation of any model is one step forward. Our approach to assess the OSU model is outlined as follows:

1. The main body of the model will be treated as a black box. No modification will be made to the working of the program.
2. Input data to the model will be chosen to best represent the materials and configurations used.
3. A data base of full-scale test results having several variables will be used for the comparison with model calculations.

The rest of this report describes in detail the methods and results of the work to assess the model.

Full-Scale Test Data

The database of full-scale tests is a collection of a series of room tests carried out at the FPL. The conditions and materials used in these tests are summarized in Table 1. There were two series of tests. In the step 1 series, the burner location and its output program

TABLE 1—*Description of room fire tests used for model validation.*

Run No.	Date	Burner Location	Burner Program	Material[a] Wall	Material[a] Ceiling
		STEP 1. SENSITIVITY STUDY			
2	4/7/88	corner	B	gypsum	gypsum
5	6/2/88	corner	B	DF plywood	gypsum
12	11/8/88	wall	A	ceramic fiber	ceramic fiber
24R	2/2/89	wall	B	ceramic fiber	ceramic fiber
25R	2/2/89	wall	C	ceramic fiber	ceramic fiber
7	11/3/88	corner	A	ceramic fiber	ceramic fiber
21	1/24/89	corner	B	ceramic fiber	ceramic fiber
22	1/25/89	corner	C	ceramic fiber	ceramic fiber
23	1/25/89	corner	D	ceramic fiber	ceramic fiber
15	11/16/88	wall	A	DF plywood	ceramic fiber
16R	3/16/89	wall	B	DF plywood	ceramic fiber
17	11/30/88	wall	C	DF plywood	ceramic fiber
18	12/8/88	corner	A	DF plywood	ceramic fiber
19	12/15/88	corner	B	DF plywood	ceramic fiber
20	12/21/88	corner	C	DF plywood	ceramic fiber
26	2/9/89	corner	D	DF plywood	ceramic fiber
		STEP 2. SELECTED WOOD PRODUCTS			
27	3/1/89	wall	B	redwood	ceramic fiber
28	3/3/89	wall	B	SP plywood	ceramic fiber
29	3/7/89	wall	B	particleboard	ceramic fiber
30	3/9/89	wall	B	OSB	ceramic fiber
31	3/14/89	wall	B	FRT plywood	ceramic fiber
32	3/24/89	corner	B	redwood	gypsum
33	3/29/89	corner	B	SP plywood	gypsum
34	4/6/89	corner	B	particleboard	gypsum
35	4/6/89	corner	B	OSB	gypsum
36	4/26/89	corner	B	FRT plywood	gypsum

[a] DF = Douglas-fir. SP = Southern pine, OSB = oriented strandboard, and FRT = fire retardant treated.

were varied to generate a range of scenarios of the ignition source. Two burner locations (corner. and wall) and four burner programs were used. Figure 1 shows the heat output programs. Program A is a constant 40 kW for 15 min. Program B is a two-step program beginning with 40 kW for 5 min, followed by 160 kW for another 5 min. Program C is a stepwise increase of 40-kW increments to 160 kW within 90 s. Program D is similar to Program B with the insertion of 100 kW for 5 min in the middle. For wall/ceiling linings. combinations of gypsum wallboard. ceramic fiber blanket. and 13-mm (0.5in.) Douglas-fir (DF) plywood were used. In the step 2 series. five other wood materials were run in either corner or wall configuration using ceramic fiber blanket ceiling for the wall series and gypsum wallboard for the corner series. These materials were DF plywood, redwood, Southern Pine (SP) plywood, particleboard. oriented strandboard (OSB), and a fire-retardant-treated (FRT) plywood. The materials. test conditions, and results were discussed previously [*10, 11*].

The 16 tests of the sensitivity study (step 1) present a challenge to the model to be able to respond to rather different scenarios. The tests in step 2 challenge the model to respond to fire properties of the materials. In a sense, step 1 evaluates the "coarse" and step 2 the "fine" tuning of the model.

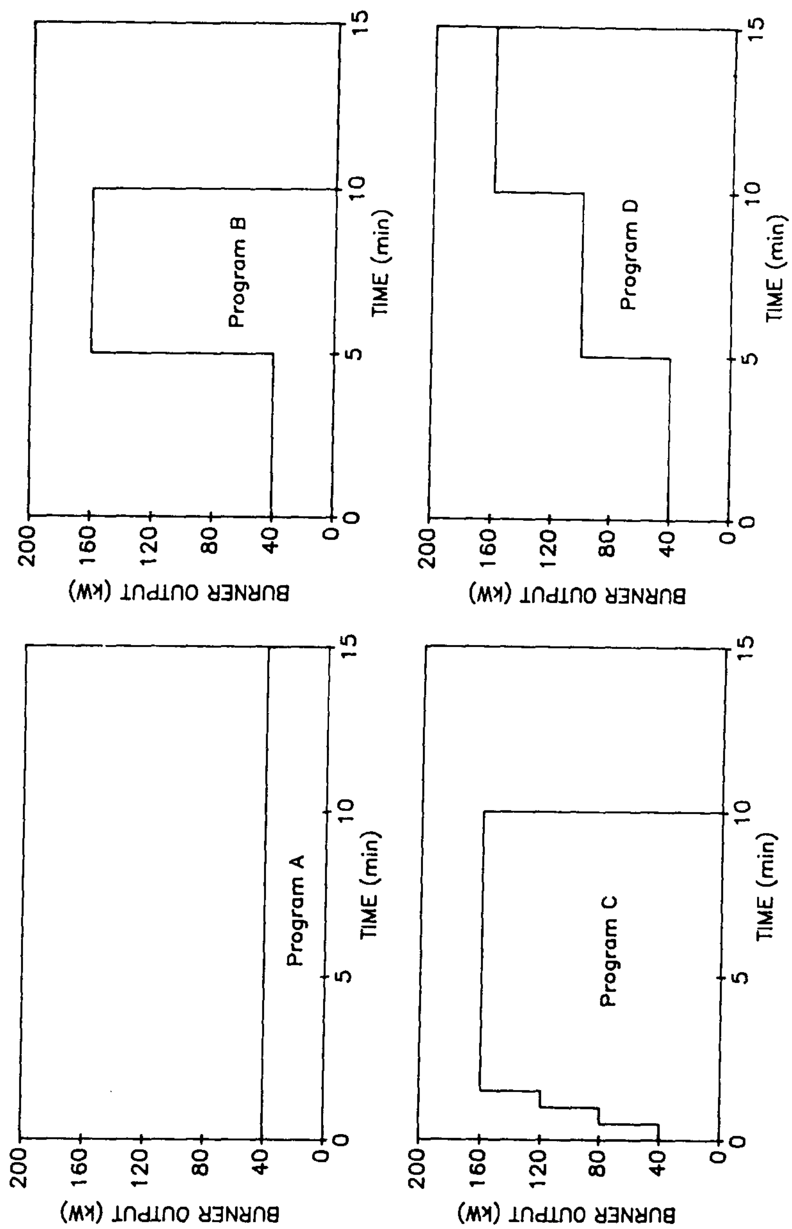

FIG. 1—*Burner programs used in sensitivity study.*

Bench-Scale Test Data

Heat and smoke release rate, ignition, and flame spread data of the wood materials were obtained in the OSU apparatus at Weyco. The materials were those used in the sensitivity study. The data were reduced following Smith's anamorphasizing procedure. The data were then used in the model simulations for comparison with the full-scale test data.

The subroutine QSUB1 describes the burner power output as a function of time. For the benchmark model, the burner was set at 40 kW for 300 s and then increased to 160 kW.

The heat and smoke subroutine RR describes the heat and smoke release of combustible wall materials. The subroutine RR2 is called for ceiling material. However. since all our ceiling materials were noncombustible (gypsum board was assumed noncombustible). the RR2 subroutine was never called.

The RR subroutine is a unique feature of how Smith presented the data. An example of how Smith reduced data from DF plywood is given here. First. rate of heat release (RHR) was expressed as a function of total heat release (THR). To scale the RHR curves, Smith used a parameter X to "normalize" the THR to the same scale. The RHR curve obtained at 50 kW/m^2 (RHR5) was represented by a third order polynomial. The RHR at lower fluxes was scaled based on this curve. In this particular case. for DF plywood, Smith divided the curves into two areas: $X < 167$ and $X > 167$. As shown in Fig. 2, the curvefit to RR data had several problems. Although the fit to the RHR5 curve was reasonably good, fits for the other flux levels were not so. Because of the transition around the X value of 167, discontinuity exists across this point.

To reduce RR data into subroutines, Smith's procedure of anamorphasizing was followed as much as possible with one modification. The RHR was assumed to remain at the minimum value after the first peak. This was done because the RHR of wood products remains almost constant if the material is thick or if there is a backing material with similar properties (gypsum board, for example). The second peak was an artifact of heat release testing where samples are backed with an insulating material. The RHR is expressed as a function of parameter X, which is a scaled value of total (cumulative) heat release (THRI)

$$X = THRI/(10 + CFLUX)$$

where CFLUX is external heat flux in W/cm^2.

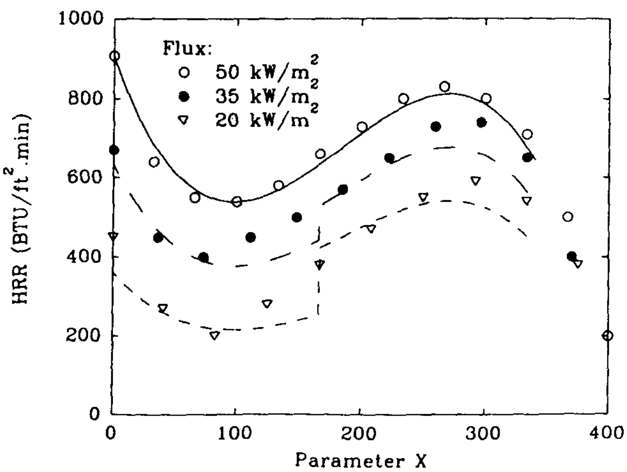

FIG. 2—*Heat release rate data for DF plywood from Smith's subroutine.*

Weyco RHR data were obtained at 6, 4, and 2 W/cm^2 of heat flux; the RR curves at 6 W/cm^2 were used as the reference curve. A third degree polynomial was fit to the RHR6 curve. A value of X where RHR6 is minimum was used to set the remaining part of the curve constant. The RHR at other flux values was then scaled based on the RHR6 curve. The RR subroutines are shown in Figs. 3 to 8. As shown in these figures. the fit to the data using this method leaves much to be desired. However, for the purpose of this evaluation. the subroutines as derived will be used to observe the model's sensitivity for RR data input.

The flame travel rate data obtained in the Weyco OSU unit for the materials as functions of flux were represented as second order polynomial of heat flux:

Material	Flame Travel Rate
DF plywood	FTR = 0.00314 + 2.8645 F + 0.32292 F^2
Redwood	FTR = -6.9598 + 4.1687 F + 0.3317 F^2
SP plywood	FTR = -4.837 + 5.9097 F - 0.1768 F^2
Particleboard	FTR = -7.2851 + 5.4390 F - 0.3380 F^2
OSB	FTR = -0.3597 + 1.3163 F + 0.6111 F^2
FRT plywood	FTR = 12.000 - 10.500 F + 2.250 F^2

where FTR is flame travel rate in units of in./min and F is heat flux in W/cm^2.

Other data obtained from Weyco for the model input are density. self-propagating flux (SPF), and minimum flux time product for ignition (FTP_{min}). (Note: All data in the OSU model are in English units of measurement.)

Material	Density (lb/ft^2)	SPF (Btu/ft^2 · s)	FTP_{min} (Btu/ft^2)
DF plywood	30.2	0.62	31.5
Redwood	26.0	0.62	34.4
SP plywood	37.5	0.66	37
Particleboard	46.5	1.33	45
OSB	38.8	0.62	31
FRT plywood	38.2	1.77	30

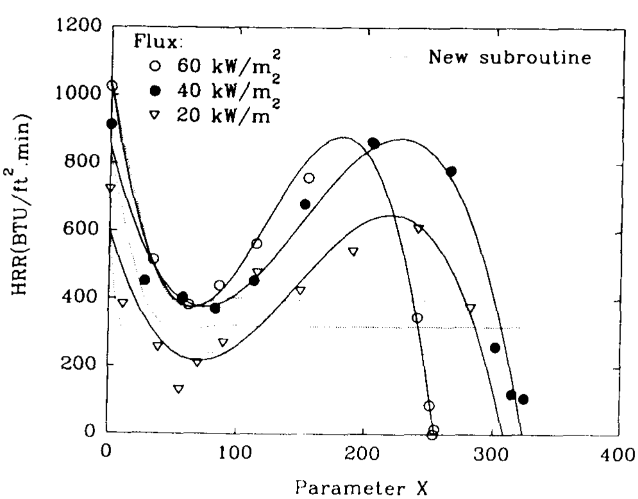

FIG. 3—*Weyco heat release rate data for DF plywood.*

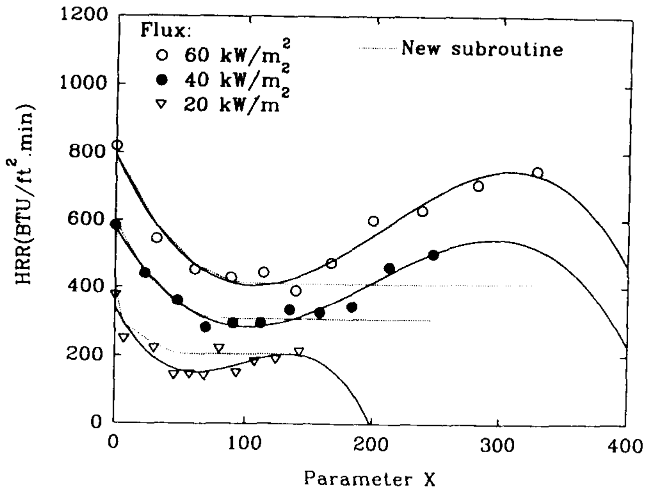

FIG. 4—*Weyco heat release rate data for redwood.*

Model and Test Data Comparison

Comparison Criteria

Three criteria were used for comparing model and experimental data:

1. Heat release rate from compartment
2. Radiative heat flux to floor
3. Upper layer temperature

Heat release rate reflects whether the model accurately accounts for burning of involved surfaces. Heat flux to the floor and upper layer temperature reflect how well the model keeps track of the heat flow. The average temperature of the upper layer depends on the interpretation of the data. Currently. the draft ASTM room test standard calls for mea-

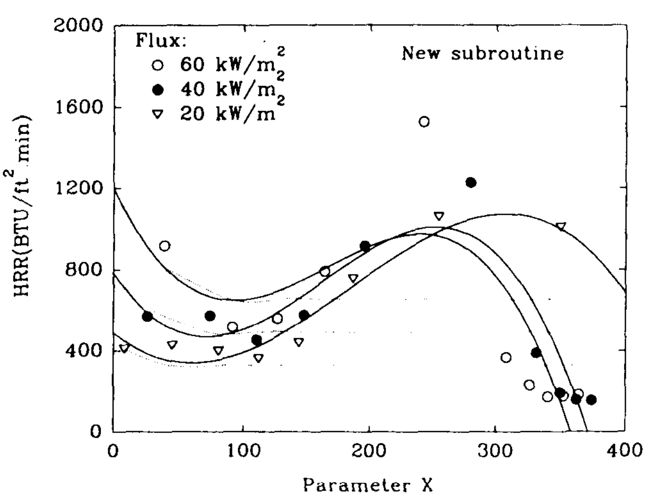

FIG. 5—*Weyco heat release rate data for SP plywood.*

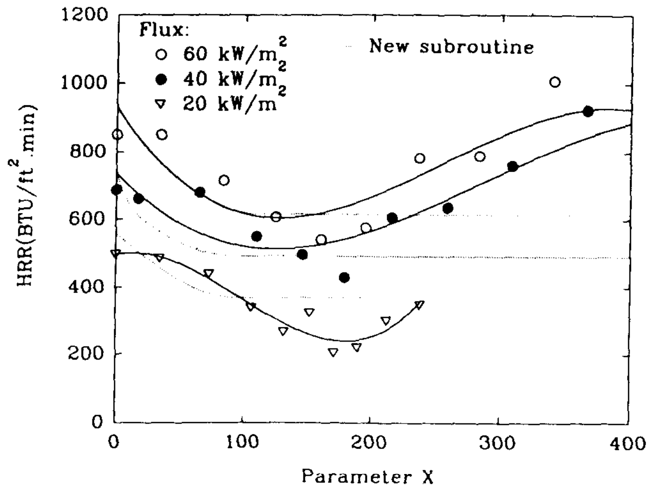

FIG. 6—*Weyco heat release rate data for particleboard.*

surement of temperature at a distance of 100 mm (4 in.) below the ceiling in the center of the room and centers of the four quadrants. Our experience shows that significant stratification of the upper layer occurs. Measurement of the average of selected temperature readings along a vertical profile at the center of the room would be more representative of the upper layer temperature. From visual observations, the upper layer seen as smoke layer almost always extends to 0.91 m (3 ft) below the ceiling. The six thermocouple readings used to calculate the average upper layer temperature are 0.1, 0.25, 0.41, 0.56, 0.71, and 0.86 m (0.32. 0.82, 1.35, 1.84, 2.33, and 2.82 ft) below the ceiling.

Other criteria can be included such as layer height. smoke generation rate, mass flow in and out of the compartment, and average layer temperatures based on zone model concept. Janssens developed a procedure to reduce the room test data to obtain these calculated data [*20*]. However, the data need to be derived from a massive amount of raw data and are not

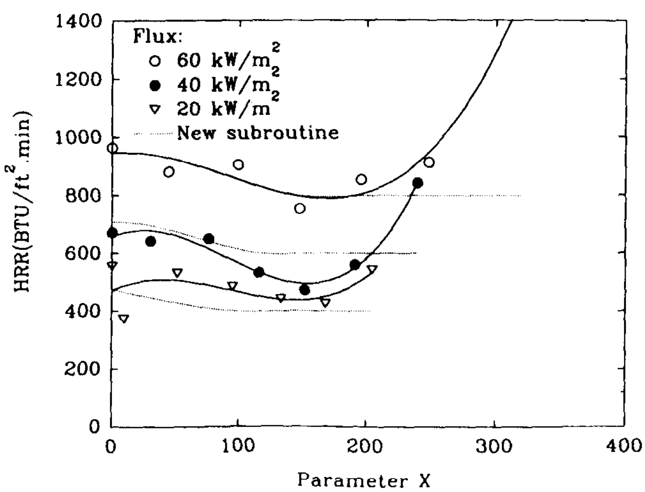

FIG. 7—*Weyco heat release rate data for OSB.*

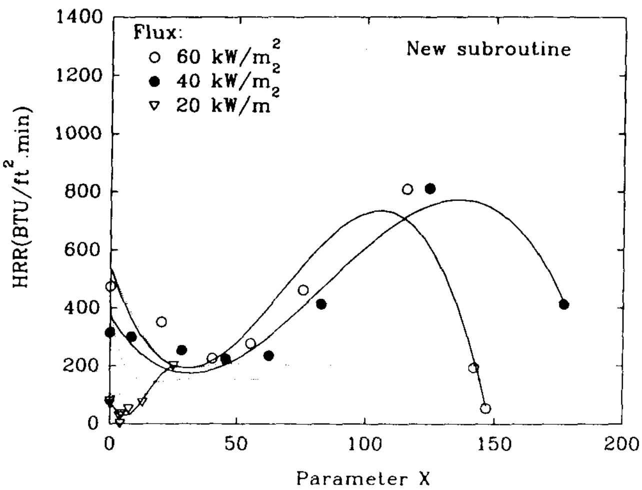

FIG. 8—*Weyco heat release rate data for FRT plywood*

yet available. The three criteria described previously represent the data most readily and commonly measured in room fire tests. Further comparisons can be made as part of the fine tuning process.

Benchmark Model

To keep the evaluation objective, a benchmark model must be kept as reference. This benchmark model is the black box that will remain literally unchanged throughout the course of the evaluation. A challenge was made to attendees of a modeling workshop organized at FPL on 22 to 23 June 1988. During this workshop, corner room test 5 with DF plywood walls was conducted. Several attempts were made to predict the fire growth and time to flashover. The OSU model was able to predict time to flashover almost exactly. However. the heat release rate and other criteria did not follow the experimental data very well. Upon revision of model run 5 (5R), using the RR data shown in Fig. 3, results agreed well with experimental data. Heat release rate. upper layer temperature, and heat flux to the floor are compared in Figs. 9 to 11, respectively. Since then. no changes have been made to the model. The model version used for that comparison is taken as the benchmark.

Comparison of Model Calculations and Sensitivity Study

The sensitivity study (step 1) had several tests with no combustibles. These tests were intended to check the model calculations of heat flow and temperature with the burner as the only fire source. There is no good way to compare data because they are time-dependent. We chose to compare selected data of average upper layer temperature and heat flux to the floor at arbitrary times (Table 2). As shown in Table 2, the OSU model consistently gave higher temperature and lower heat flux to the floor than the experimental data. This is interesting because upper layer temperature is used to calculate radiative heat flux to the floor. This suggests that the model needs improvements in calculating upper layer temperature and also radiation from the upper layer.

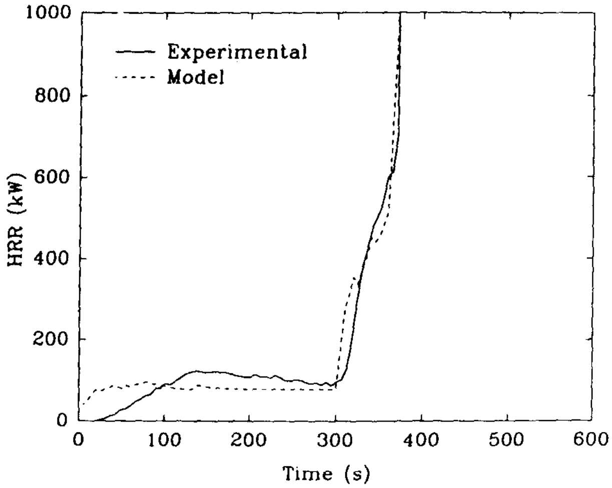

FIG. 9—*Benchmark model data and experimental data on* heat release rate

Flashover Times

Table 3 lists flashover times of DF plywood tests with different burner programs. In Table 4, model calculations are compared to results of tests of different wood products with burner program B. The chosen flashover criterion was a heat flux to the floor of 20 kW/m^2.

For the DF plywood series (Table 3). run 5 is the benchmark and agreement is excellent. Except for 16R, the wall tests with DF plywood did not reach flashover conditions. The model showed no flashover for all the DF plywood wall tests. Agreement between the experimental data and model simulations was reasonable for the corner tests. Except for run 18 with burner Program A. the tests had flashover times within 36 s of each other.

In the series of different wood materials with burner Program B (Table 4). the model failed to simulate flashover conditions of the wall tests where flashover was reached exper-

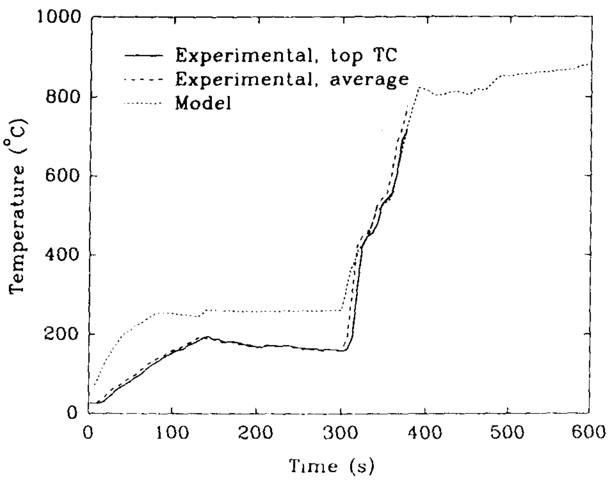

FIG. 10—*Benchmark model data and experimental data on upper layer temperature*

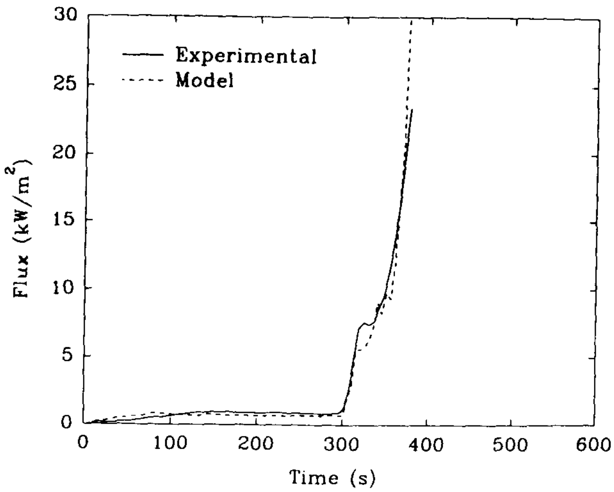

FIG. 11—*Benchmark model data and experimental data on heat flux to the floor.*

imentally. For the corner scenarios, the occurrence of flashover was predicted correctly but agreement of time to flashover was poor in some cases. In this series of simulations. the only variables were the heat release rate and flame spread data of the wood materials. The relatively wide range of flashover times indicates that the model is quite sensitive to RHR and flame travel input data. Because of this sensitivity. further emphasis must be given to the way the data are obtained and represented. Numerous problems have been documented with the OSU heat release apparatus to measure heat release rate [*21*]. Furthermore. the flame travel data obtained over the 20-mm (0.79-in.) distance in this apparatus is nonstandard and not repeatable.

TABLE 2—*Test and model upper layer temperature and heat flux to floor.*

Run No.	Burner Location	Material	HRR, kW	Time, s	Temperature. °C		Flux, kW/m^2	
					Test	Model	Test	Model
2	corner	gypsum	40	300	95	183	0.5	0.2
			160	600	234	355	2.9	1.9
12	wall	ceramic fiber	40	600	114	182	0.8	0.2
24R	wall	ceramic fiber	40	300	108	168	0.7	0.2
			160	600	274	335	4.6	1.8
25R	wall	ceramic fiber	160	600	284	350	5.1	2.0
7	corner	ceramic fiber	40	600	124	232	0.9	0.3
21	corner	ceramic fiber	40	300	125	211	0.8	0.3
			160	600	296	405	5.9	2.6
22	corner	ceramic fiber	160	600	297	418	6.0	2.8
23	corner	ceramic fiber	40	300	124	211	0.8	0.3
			100	600	220	340	2.8	1.3
			160	900	293	420	5.8	2.8

TABLE 3—*Flashover times for tests with DF plywood compared to model data.*

Run No.	Location	Burner Program	Ceiling Material	Flashover Time, s	
				Test	Model
5	corner	B	gypsum	376	370
15	wall	A	ceramic fiber	none	none
16R	wall	B	ceramic fiber	378	none
17	wall	C	ceramic fiber	none	none
18	corner	A	ceramic fiber	618	400
19	corner	B	ceramic fiber	330	315
20	corner	C	ceramic fiber	120	120
26	corner	D	ceramic fiber	366	330

Agreement with full-scale results depended on not only the ability of the model to calculate but also the accuracy of the input data. At the moment, we do not know how to quantify the "agreement" between model and experimental data. This is a subject that will be open to serious future debate by validation experts.

Conclusions

Several conclusions can be drawn from this study:

1. Simulations of calibration runs with noncombustible linings showed that the OSU model overestimates upper layer temperature and underestimates the heat flux to the floor at given rates of heat release. This suggests that the physics of the model needs to be revised.
2. The data reduction process of heat release rate of the materials needs to be improved. This study showed that heat release rate is perhaps the most important input in the OSU model, and therefore results depend significantly on these inputs. Unfortunately. the OSU model still has a very rudimentary input of heat release rate and flame travel rate data. The accuracy of the input data obtained from the OSU apparatus is also questionable.

TABLE 4—*Flashover rimes for tests with other wood materials compared to model data.*[a]

Run No.	Burner Location	Material		Flashover Time, s	
		Wall	Ceiling	Test	Model
27	wall	redwood	ceramic fiber	348	none
28	wall	SP plywood	ceramic fiber	366	none
29	wall	particleboard	ceramic fiber	360	none
30	wall	OSB	ceramic fiber	336	none
31	wall	FRT plywood	ceramic fiber	none	none
32	corner	redwood	gypsum	378	430
33	corner	SP plywood	gypsum	348	100
34	corner	particleboard	gypsum	342	410
35	corner	OSB	gypsum	270	100
36	corner	FRT plywood	gypsum	none	none

[a] All tests used burner Program B.

3. The OSU model consistently failed to track the fire development in the scenario of the burner against the back wall (wall tests). The OSU model did reasonably well with the corner scenario, where flashover was predicted actually with some degree of agreement. As written, the statement issued by the model did not reflect how good the agreement is.
4. Because of the complexity of comparing model simulations and experimental results. there is a critical need for clear and complete documentation of the "validation" process.
5. Finally, this study indicates that extreme care, not exclusive to the OSU model, needs to be devoted to the process of model validation and verification. The model must meet several criteria to be considered "valid." It must give reasonable agreement with a diversity of scenarios and with a variety of materials. The degree of agreement must be standardized in some fashion so that statements about reasonable agreement can be made. At this time, model validation is still not possible because we lack knowledge about how good is "good enough."

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