Final Environmental Specifications to be Included in the Bid Documents for Office Furniture Systems

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State of California, Department of General Services, Procurement Division

Prepared by

Hal Levin (Indoor Air Quality)
Building Ecology Research Group
2548 Empire Grade, Santa Cruz, California 95060
Phone: (831) 425-3946; Fax: (831) 426 6522
email: hlevin@cruzio.com

Leon Alevantis (Indoor Air Quality)
California Department of Health Services
2151 Berkeley Way, Berkeley, CA 94704
Phone: (510) 540-2132; email: lalevant@dhs.ca.gov;

Rick Muller (Recycled Contents)
California Integrated Waste Management Board
8800 Cal Center Drive, Sacramento, CA 95826
Phone: (916) 255-2359; email: rmuller@ciwmb.ca.gov;

Gary Flamm (Lighting)
California Energy Commission
1516 9th Street, Sacramento, CA 95814
Phone: (916) 654-2817; email: gflamm@energy.state.ca.us;

Submitted by
WorldBuild Technologies
110 Sutter Street, Suite 712, San Francisco, California 94104
Phone: (415) 352 5200, Fax: (415) 352 5210
www.worldbuild.com

Contract Manager
Kathy Frevert, California Integrated Waste Management Board

SECTION A

TESTING REQUIREMENTS FOR VOLATILE ORGANIC COMPOUD EMISSIONS

Introduction

The test requirements described in this specification are intended to ensure good indoor air quality in office spaces where office furniture systems are installed. The requirements for measuring volatile organic compounds (VOCs) emitted from office furniture systems included in this specification, use, to the greatest extent possible, standardized procedures (including analytical test methods, test chamber conditions, specimen acquisition and handling, and conditioning). Cost of measuring VOCs emitted by office furniture systems is deemed reasonable as it is a very small fraction of total acquisition costs, which are estimated at $60M over the three-year contract period. It is estimated that the testing procedures will cost less than the retail purchase price of one workstation.

Submittal Requirements for Indoor Air Quality

1. All bidders are required to submit the indoor air quality results no later than fourteen (14) calendar days after the bid due date (the fourteen day grace period does not apply to the re-bid process. The reported concentrations shall not exceed the maximum concentrations listed herein. Submitted report shall include a complete description of the following:

    a. Test chamber conditions as specified in Section A1.1.3.
    b. Sample collection and analysis as specified in Sections A1.1.6, A1.1.7, A2, and A3.
    c. Documented history of each component (including manufacture date, storage conditions, storage duration) as required in Section A1.1.1.b.
    d. Calibration and quality assurance methods as described in Section A.1 (fifth bullet) and Section A.1.1.6.f
    e. The limits of detection for all chemicals reported as below-detection.
    f. Fabric testing results only for those fabrics significantly distinct from a chemical perspective from the one(s) tested with the workstation, or a signed certificate provided by the furniture manufacturer, testing laboratory, or by the fabric supplier for those fabrics not significantly distinct from the one(s) tested. When multiple fabric options are offered on office furniture systems vertical panels, fabric tests performed in small chambers may be used in conjunction with the full workstation tests to verify compliance with this specification. Only fabrics that are significantly distinct from a chemical perspective need be so tested. The emissions from fabrics shall be evaluated and reported according to criteria specified in Sections A2 and A3.
    g. Information addressing recommended maintenance, cleaning, refinishing, and disposal procedures as specified in Section B.
    h. Packaging systems as described in Section B.

2. **Formaldehyde Requirement**: If you cannot meet the 20 ppb formaldehyde requirement at the time you submit the indoor air quality test results of your product(s) to the State, you are required to submit the following information in addition to all the other test results required by this specification: (a) the formaldehyde concentration emitted by your office furniture under the test conditions described in this specification (maximum acceptable concentration is 50 ppb); and (b) a description of the actions already taken and plans to meet the 20 ppb formaldehyde limit within 12 months. If you are the selected bidder and you do not meet the 20-ppb requirement, the State will require you to comply with the 20-ppb requirement within 12 months of the issuance of the contract. If the 20-ppb requirement is not met within 12 months, the contractor will be placed in default in accordance with the General Provisions, Sections 24, Termination For Default.

Manufacturer Warranty
The manufacturer shall warranty that their products continue to comply with the specifications described herein for the duration of the contract and that upon further testing at the discretion and expense of the State of California, their products' emissions will not exceed the maximum concentrations listed herein by more than 50% . The State reserves the right to test furniture at its own cost following the test protocol described in this specification and at any time these specifications are in effect. In the event that a manufacturer changes the components or suppliers for its products under this specification, resulting in change of the chemical emissions of these components, it shall notify the State of California in advance of these changes and, at its discretion, the State may require additional testing following the test protocol described in this specification at the manufacturer's own cost.

A1. Environmental Chamber Test to Measure Emission of VOCs from Office Furniture Systems
This test is applicable to large specimens that require testing of component assemblies or large sheets of material that cannot be accommodated in small to medium sized environmental chambers. The test is used to screen complete workstation specimens for emissions of volatile organic compounds (VOCs), SumVOCs (SumVOC) and formaldehyde at standardized environmental conditions over a period of 96 hours.

At the present time the State does not accredit laboratories for measuring emissions from office furniture systems. Any testing laboratory will be acceptable as long as the methods described herein are followed and documented. The State is aware that the large environmental chamber emission tests can be conducted by Air Quality Sciences in Georgia (contact: Marilyn Black, Ph.D., 1337 Capital Circle, Marietta, GA 30067, Phone: 770-9333-0641; Fax: 770-933-0641; email: mblack@aqs.com; http://www.aqs.com) and by Bodycote Technitrol in Point Claire, Canada (contact: Steve J. Bodzay, Ph.D. Vice President Industrial Expertise, 121 Hymus Blvd., Pointe Claire, QC H9R 1E6 tel: 514-697-3273 (234); fax: 514-697-2090 bodzay.s@bodycote-mt.com web site at: http://www.bodycote-mt.com The small environmental chamber emissions

tests can be performed also by Berkeley Analytical; 904 Wright Avenue, Suite 12, Richmond, California 94804; telephone 510.236.2325; email: berkeleyanalytical@att.net. This laboratory will be offering large environmental chamber emission test services in 2001. These laboratories are listed for information only and are not endorsed or certified by the State of California. Other laboratories may also be capable of offering acceptable environmental chamber testing services.. This testing protocol is based in part on a previously developed testing protocol as cited in *Reducing Occupant Exposure to Volatile Organic Compounds (VOCs) from Office Building Construction Materials: Non-Binding Guidelines* (DHS, 1996). Except as noted below, it is essentially identical to the *Large Chamber Protocol for Measuring Emissions of VOCs and Aldehydes from Office Workstations*, (also published as *Large Chamber Protocol for Measuring Emissions of VOCs and Aldehydes*), produced by Research Triangle Institute under a cooperative agreement with the United States Environmental Protection Agency's (EPA's) National Risk Management Laboratory, Office of Research and Development, Research Triangle Park, NC. The protocol was published in September 1999. The office furniture manufacturers were involved in the development of the protocol through the Business and Institutional Furniture Manufacturer's Association (BIFMA International) and individual representatives participated in the protocol development process as did other stakeholders. The protocol (referred to hereinafter as "EPA-RTI Protocol") is available on the World Wide Web at: http://etv.rti.org/iap/documents.cfm (RTI site), or http://www.epa.gov/etv/test_plan.htm#prevention (EPA site).

Major differences between requirements of this specification and the EPA-RTI protocol are as follows:

- This specification requires product conditioning for ten days at the testing laboratory prior to testing in order to reduce short-term emissions including but not limited to those from sink effects during the final stages of manufacturing. This will result in the test more closely simulating the emissions that will actually occur when the selected furniture, produced as per other requirements of this specification, is installed in an actual office environment. The conditioning can be done in the chamber under the test conditions of the 168-hr EPA-RTI ETV protocol followed by an additional three days of airing out, thus making the protocol of this specification compatible with that of EPA-RTI. Alternatively, conditioning can be done in a separate space established for that purpose.
- The environmental chamber test duration required by this specification is only 96 hours rather than 168 hours required by the EPA-RTI ETV protocol. This change will significantly reduce the cost of the test. When followed in conjunction with the conditioning period, it will not compromise the reliability and usefulness of the test results. Where conditioning is done in the chamber, samples can be collected under the EPA-RTI ETV protocol requirements if the more extensive results specified by that protocol are required by the manufacturer.
- The collection of samples required by this protocol is at only three time points rather than the six specified by EPA-RTI. These changes will significantly reduce the cost of the test without compromising the reliability of the results if other requirements of this specification are met.

- The emissions tests will be conducted at 1.0 air changes per hour. However, under this specification, an air change rate of 0.5 air changes per hour (ach) will be used to calculate expected concentrations attributable to emissions from the tested products in State of California office buildings. The 0.5 air change rate most closely approximates the weekly average air change rate in much of the current inventory of State office buildings of varying ages. It slightly underestimates ventilation in some newer buildings (during economizer cycle operations) and overestimates ventilation in some older buildings (without economizers designed to provide only 5 cfm/person of outdoor air ventilation under all operating conditions). The lower air exchange rate will increase chamber concentrations but tend to reduce emission rates.
- Calibration of the analytical instruments shall be done using commercially available pure standards for the compounds listed in Section A.1.1.6.f. Use of this method of calibration will not invalidate results obtained under the EPA-RTI ETV protocol. Such calibration shall be part of the testing laboratory's on-going quality assurance plan and need not to be performed prior to each workstation test.
- Background VOCs in the chamber specified in this protocol are more realistically achievable and less stringent than those specified in the EPA-RTI ETV protocol. More specifically, the EPA-RTI ETV protocol specifies the background concentrations must not exceed 2 $\mu g/m^3$ for formaldehyde (this protocol specifies 5 $\mu g/m^3$), 10 $\mu g/m^3$ for TVOC (this protocol specifies 25 $\mu g/m^3$), and 2 $\mu g/m^3$ for any individual VOC (this protocol specifies 5 $\mu g/m^3$).
- Where alternate fabrics for vertical panels are submitted as options, small environmental chamber tests of fabrics alone are used rather than large environmental chamber testing of complete workstations with each alternative fabric (see Section A3). This issue is not addressed in the EPA-RTI protocol.
- Criteria for screening products on the basis of 96-hr test results are included in this specification. This subject is not addressed by the EPA-RTI protocol.
- The EPA-RTI protocol does not specify the size and the components of a "standard workstation". The specification provides such information (see Figures 1 and 2).

A1.1 Testing Requirements

The test shall be conducted following the guidelines of ASTM D5116-97 and the EPA-RTI ETV protocol except as noted above and in the remainder of this specification. Where differences exist between the specific requirements of the two documents mentioned here and those of this specification, the requirements of this specification shall prevail. Figures 1 and 2 attached at the end of this specification define California's standard workstation based on a six-pack configuration and the workstation configuration to be tested for VOC emissions.

Test Specimen Acquisition and Handling

Specimen Packaging And Shipping

The test specimens shall be packaged at the manufacturing location immediately after the final stage of the normal manufacturing process and prepared in the normal manner for shipping to an installation site. This package shall be delivered to the test facility without storage or other delays. Care shall be taken not to expose the specimens to extreme heat or cold.

The specific details for the test are as follows:

1. ***Specimen Handling***
   a. Ten days prior to the initiation of the chamber test at the test facility, the specimen components shall be unwrapped and placed in a conditioning room and kept there for the entire 10 days. The laboratory shall remove the packaging and shall transfer the specimens to the conditioning space (or environmental chamber as described below) for conditioning, and then directly to the environmental chamber which has been pre-conditioned for the test.
   b. The history of the specimen of each workstation component, including the manufacturing dates, storage conditions, and storage duration, shall be documented and submitted with the test results.

2. ***Conditioning Room Specifications:***
   a. The conditioning room shall provide at least 3 air changes per hour of outdoor air at temperatures between 20 and 27 °C. No conditioning room air recirculation is permitted in order to ensure that VOCs emitted from the test specimens are exhausted to the outside and are not adsorbed on the specimen surfaces.
   b. The conditioning room can be any space within a conditioned building, even the laboratory building, where the specified conditions can be met. Ventilation can be provided using transfer or supply air from the building rather than a direct outdoor air supply. Relative humidity shall be 50% ±15%. The air in the conditioning room shall be well mixed, using fans as required. The conditioning room may be the environmental chamber or another space with adequate environmental control. If other (non-workstation) samples are in the same conditioning room, they shall be separated by no less than 12" from workstation components. The workstation sample shall be transferred directly from the conditioning room to the environmental chamber with no avoidable exposure to sources of VOC contamination or extreme temperatures.

3. ***Environmental Test Chamber Specifications:***
   a. The workstation test shall be conducted in an environmental chamber capable of accommodating the entire workstation as specified in the Request for Proposals. The chamber surfaces, including the interior surfaces of the ductwork and HVAC components, shall be chosen for their low or negligible ability to emit or adsorb VOCs. These surfaces shall be constructed of stainless steel, aluminum, or glass. In addition, non-VOC emitting and non- VOC adsorbing material shall be used to seal openings and joints. Differences between chamber air and chamber surface temperatures shall be minimized. The environmental chamber shall be fully capable of controlling outdoor,

supply, return, and exhaust air flow rates, air velocities, air mixing, temperature, and humidity. Each of these parameters shall be monitored throughout the test and the results shall be included in the report. Measures shall be implemented to ensure that the chamber air is well mixed as specified below. The size of the chamber shall be at least 25 m^3.

b. The locations, airflow characteristics, and number of inlets and outlets for air supply and circulation shall be capable of providing sufficient air mixing within the chamber. The air flow through the chamber may include recirculated plus clean air. If there is adequate mixing achieved with fans, there is no need for recirculation. Mixing shall be evaluated by tracer gas tests in the empty chamber following ASHRAE Standard 129 (ASHRAE, 1997). Tracer gas concentrations should be within five percent of the theoretical well-mixed model concentrations.
c. The chamber ventilation rate shall be 1.0 air changes per hour (ACH) of clean air. Air change rate shall be measured by tracer gas tests following ASTM Standard E741-95, "Standard Method for Determining Air Change in a Single Zone by Tracer Gas Dilution." The chamber ventilation rate may also be determined by air flow measurement instrumentation that have been calibrated by the tracer gas method. Such calibration shall be performed at least once a year as specified in the EPA-RTI ETV testing protocol.
d. Background concentrations in the empty chamber ventilated at 1.0 ach shall not exceed 5 $\mu g/m^3$ for any individual VOC, 25$\mu g/m^3$ for TVOC, and 5 $\mu g/m^3$ for formaldehyde. Chamber background and supply air concentrations of these components during the test shall be measured and reported.
e. Air velocities in the chamber shall be maintained between 0.075 and 0.125 m/s to simulate a building environment. Local air velocities shall be measured 1 cm from specimen surfaces at no less than five representative locations. Air velocity measurements also shall be made at 0.3 and 1.2 meters above the floor at three representative locations.
f. The test chamber temperature shall be 23 °C ±2 °C. Relative humidity shall be 50% ±5%.

4. ***Assumptions Used for the Specific Test Requirements***

In order to calculate allowable concentrations, it is necessary to make several assumptions and to compute the area and the associated building volume of the workstation as a fraction of the total locally-ventilated floor area.

a. Loading Ratio
   i. It is necessary to determine the loading ratio of the workstations in realistic office environments and to compare this ratio to the loading ratio in the chamber. Typical volumes of environmental chambers range between 20 and 50 m^3.
   ii. For purposes of this specification, it is assumed that building occupancy is one person per 130 square feet (12.0 square meters) of office floor space. This is based on an standard 8ftx8ft workstation as shown on Figure 1, and

accounting for circulation (traffic area), and support space such as conference rooms, files, storage, etc.

iii. It is assumed that the free height of the space within which air is circulated (supply and return) is 9 feet (2.74 m). This accounts for space not occupied by solid objects between the floor and ceiling and space above a suspended ceiling. Air supply and return ductwork and control components enclosing air flow are part of the building volume for calculating air exchange rate. The building volume per workstation then is 12 x 2.7 or 32.4 m^3 (rounded to 33 m^3 per workstation.

iv. To determine the ratio, divide the volume of the chamber [Vch] by the assumed building volume per workstation.

b. Ventilation Rate

i. The ventilation rate plays an important role in determining concentrations. Not only does dilution ventilation reduce concentrations, but the air concentrations can influence the emission rates. Therefore, it is important to use realistic ventilation rates that reflect those in the actual office environment. Additionally, during HVAC off-periods, there is considerable sorption to surfaces, especially to carpets and to office systems vertical panels which can be 2 to 4 times greater surface area than the floor area, depending on density and partition height and configuration. Sink effects are considerable, and therefore desoprtion or re-emission are strongly dependent on airborne concentrations in the boundary layer immediately above the surface as well as sink material and chemical compound. Therefore, an average weekly ventilation rate must be calculated accounting for operational and non-operational times of the HVAC system.

ii. It is assumed that the minimum air exchange rate in an office environment during occupied hours will be approximately 0.8 h^{-1} based on California Energy Commission's Title 24 (CEC, 1999) minimum ventilation rate of 15 cubic feet per minute per person (cfm/p) for office environments and typical office densities and ceiling heights.

iii. It is further assumed that the ventilation system will be operated approximately 55 hours per week (approximately 1/3 of the total hours of the week). This is based on 11 hours/day, 5 d/wk operation. It accounts for the Energy Commissions requirement of operating the HVAC system one hour prior to occupancy.

iv. It is assumed that the average air exchange rate during non-operational hours will be $0.3h^{-1}$ based on Persily et al. (1989), Persily, (1998); Grot et al. (1989); and Hodgson et al. (1989).
v. Therefore, the weekly average air exchange rate is $[(0.3 \times 113) + (0.8 \times 55)]/168 = 0.46\ h^{-1}$ or approximately $0.5\ h^{-1}$.
vi. Therefore, the test results shall be used to calculate a concentration at an air exchange rate of $0.5\ h^{-1}$ in order to best approximate the expected average ventilation rate for office environments.

5. *Test Duration*

The duration of test shall be 96 hours, or more, at the manufacturer's option. However, the results obtained at 96 hours are required for compliance to this specification.

6. *Sample collection and analysis:*

Air samples shall be collected and analyzed for total VOCs (TVOC), individual VOCs and formaldehyde (or total aldehydes, with formaldehyde reported separately).

a. Air samples for VOCs and TVOC shall be collected on a multi-sorbent sampler. The sampling and analysis method shall be validated and supporting documentation for the validation procedures and results shall be submitted with the test results and other reporting required by this specification. Standard methods shall employ internal markers such as bromofluorobenzene and/or deuterated compounds to serve as QC checks for sampling and GC/MS performance.
b. Formaldehyde shall be collected on DNPH cartridges and analyzed according to standard procedures (ASTM D 5197-97 "Standard Test for Formaldehyde and other Carbonyl Compounds in Air (Active Sampler Methodology)".
c. Samples shall be collected for analysis for TVOCs and formaldehyde at 6, 24, and 96 hours and for individual VOCs at 96 hours. Results shall be reported for TVOCs and formaldehyde at 6, 24, and 96 hours and for individual VOCs at 96 hours.
d. TVOC shall be quantified using a Flame Ionization Detector (FID) calibrated with toluene or another hydrocarbon reference compound such as hexane or decane. These TVOC samples are required for quality control purposes and not used to determine specimen acceptability. The TVOC samples are used to demonstrate that concentrations are consistent, i.e., declining with time.
e. VOC samples shall be analyzed by Gas Chromatograph – Mass Spectrometer (GC-MS). Compounds representing at least 75% of the total mass of the VOCs collected shall be identified. Any peak whose area is greater than 10% of the total area of peaks in its class shall be identified and quantified in each of the following classes of compounds:

Alkanes
Aromatic hydrocarbons
Terpenes
Halocarbons

Esters
Aldehydes and ketones (excl. formaldehyde)
Other

(Reference: the European "TVOC" list [attached] and the list of compounds in the EPA-RTI Protocol)

f. If identified in a sample, compounds on the target list shown in Appendix A shall be quantified. Additionally, compounds representing the ten largest chromatographic peaks shall be quantified if they are not on the list. Calibrations shall be made relative to the responses of the components listed below. Pure standards shall be used for calibration of these components. The testing laboratory shall, on at least quarterly basis, validate the results of their own in-lab sampling and calibration methodology, by testing VOC atmospheres supplied by certified commercially-prepared cylinder gases, and/or by certified mixed liquid standards (preferably NIST traceable). Expiration dates of calibration standards shall be reported with test results. Multi-point calibrations (minimum of four) for each component shall be performed bracketing the anticipated concentration range. Calibration cylinders are commercially available, and the contents consist of multi-component VOCs at various concentrations. Validation of the following components or their equivalents must be performed by the testing laboratory. The most recent calibration results must be reported with test results.

Aromatics and Others: Benzene, toluene, ethylbenzene, o,m,p-Xylene, and styrene
Aliphatics: n-Hexane
Cycloalkanes: Methylcyclohexane
Terpenes: Alpha-Pinene
Alcohols: Ethanol
Ketones: Methylisobutylketone
Halocarbons: 1,1,1-trichloroethane
Esters: Butylacetate

Calibration standards for all the chemicals listed above are commercially available by at least two suppliers (BOC and Scott). Substitutions of similar compounds for those listed above are allowable, in order to conform to commercially available VOC calibration mixtures. More reactive and polar compounds such as aldehydes, glycols, and acids may be calibrated based on the selection of a single component for each class. Also, calibrations for reactive VOCs are not easily NIST traceable and, therefore, fresh calibration standards must be prepared in the laboratory.

7. *Data Analysis and Test Report*

Data analysis and reporting shall be performed according to ASTM Standard 5116-97. The test report shall include complete descriptions of the test system, all analyses, and results. All quality assurance/quality control (QA/QC) procedures shall be reported.

8. ***Calculating Adjusted VOC Concentration from Large Chamber Emission Tests***
Chamber emission test results shall be expressed as adjusted concentrations calculated according to Equation 1.

Equation 1

Adjusted VOC concentration =

$$\frac{\text{Chamber VOC concentration x Volume of chamber}}{\text{Volume per workstation}}$$

Written in symbols, Equation 1 looks like this:

$$VOCadj = (VOCch \times Vch) / Vws.$$

Where

VOCadj = the adjusted VOC concentration
VOCch = VOC concentration in the chamber as measured in the test
Vch – Enclosed volume of the test chamber
Vws = The assumed building volume per workstation

The assumed volumetric density of workstations is 33 m^3 per workstation for the 8 ft x 8 ft workstation. Therefore, the Vws used in the calculation shall be 33 m^3 for the 8 ft x 8 ft workstation.

A2. Concentration Limits at 96 hours

1. To determine whether the workstation meets the requirements of this specification, calculate the adjusted 96-hr concentration according to Equation 1 in Section A1.1.8. The concentration limits of specific chemical compounds and/or classes of chemical compounds are based on relevant guidelines for odor, irritation, toxicity and other health-related criteria.
2. The VOC limits under this specification are the maximum allowable 96-hr adjusted concentrations in Table 1 below based on an air change rate of 0.5 hr^{-1}. The loading rate is one 8ftx8ft test workstation per 33 m^3 as shown in Figure 2. The test workstation configuration lacks some vertical panels in order to more accurately represent the contribution of emissions from a workstation in the six-pack configuration where some panels are shared with other workstations (see footnote in Figure 2 for calculations). The VOC Limits listed in Table 1 are recommended by the European Collaborative Action in a report entitled *Guidelines for Ventilation Requirements in Buildings* (European Commission, 1992 [as cited in DHS, 1996]). These recommendations are based on research reported by Bernd Seifert at Indoor Air '90 (Seifert, 1990). They reflect reasonable goals based on measurements of VOCs in

indoor air. Although it is termed a "TVOC" guideline by Seifert, it is actually based on the analysis of individual compounds. The general method is to quantify the ten most prevalent compounds in each of seven chemical classes. The guideline specifies that the summed concentrations in each class shall be below the maximums listed in Table 1. A summed VOC (sumVOC) concentration for all classes is calculated by adding the totals from each individual class with a guideline concentration of 300 $\mu g/m^3$ for the total.

Table 1. VOC Limits at 96 hours
Maximum Allowable Adjusted Concentrations for Seven Chemical Classes of Volatile Organic Compounds (VOC) in Indoor Air*
[based on European Commission (1992) as cited in DHS (1996)].

Chemical class of VOC	Concentration ($\mu g/m^3$)
Alkanes	100
Aromatic hydrocarbons	50
Terpenes	30
Halocarbons	30
Esters	20
Aldehydes and ketones (excl. formaldehyde)	20
Other	50
Target guideline value (sumVOC)	300
* Compounds for each class are listed in Appendix A. Compounds in each class exceeding 10% of the total peak in their class shall be identified and quantified.	

The VOC Limits shown above are generally consistent with typical VOC concentrations found in office buildings as reported in recent literature (Girman, 1999; Shields, Fleisher, and Weschler, 1996; Hodgson, 1999; Daisey *et al*, 1994).

The European Collaborative Action has additionally developed a list of 65 target compounds to be minimally included in studies of indoor air quality. The list is presented in a report entitled *Total Volatile Organic Compounds (TVOC) in Indoor Air Quality Investigations* (European Commission, 1997). This list is attached as Appendix A and is incorporated as the minimal list of target compounds for this specification.

The individual compound concentrations shall be summed by chemical class as given in Table 1. SumVOC for all quantified compounds shall also be determined. Measured concentrations will be considered acceptable if they do not exceed the VOC Limits in Table 1.

Formaldehyde
Based on the current OEHHA's acute 1-hour Reference Exposure Level (REL) of 76 ppb (94 $\mu g/m^3$), an exposure level of 27 ppb (33 $\mu g/m^3$) can be extrapolated based on an 8-hour exposure period (OEHHA, 1999) (1-hour REL also available on the world wide web at:
http://www.oehha.org/risk/chemicalDB/acutereference.asp?name=formaldehyde&number=50000). Since it is likely is that there will be other sources of formaldehyde in the space including, but not limited to paints, insulation, casework, textiles, and ceiling tiles (CARB, 1991), a lower formaldehyde limit for the workstation is established.

The maximum adjusted formaldehyde concentration in the chamber from workstations shall not exceed 20 ppb or 25 $\mu g/m^3$ above the chamber background concentration Based on information published by the California Air Resources Board (CARB, 1996) this requirement can be met either by using selected coated urea formaldehyde wood products or phenol-formaldehyde wood products. Additionally, alternative resins may need to be used in the manufacturing of fiberglass acoustical insulation boards.

NOTE: If you cannot meet the 20 ppb formaldehyde requirement at the time you submit the indoor air quality test results of your product(s) to the State, you are required to submit the following information in addition to all the other test results required by this specification: (a) the formaldehyde concentration emitted by your office furniture under the test conditions described in this specification (maximum acceptable concentration is 50 ppb); and (b) a description of the actions already taken and plans to meet the 20 ppb formaldehyde limit within 12 months. If you are the selected bidder and you do not meet the 20 ppb requirement, the State will require you to comply with the 20 ppb requirement within 12 months of the issuance of the contract. If the 20 ppb requirement is not met within 12 months, the contractor will be placed in default in accordance with the General Provisions, Sections 24, Termination For Default.

A3 Individual Fabric Tests

A3.1 Test Method
Where multiple fabric options are offered as alternates, fabrics that are significantly distinct from a chemical perspective from that tested with the complete workstation need be so tested. As an alternative to meeting the requirement for testing the entire workstation, alternate fabrics may be tested separately in small chambers following ASTM D5116-97. The emission test shall be conducted at 0.5 ach. The fabric shall be conditioned for ten days at 1 ach prior to the conduct of the emission test. Loading ratios shall be 1.5 m^2 of fabric per m^3 of chamber volume. Samples shall be collected at the same times and for the same substances as in the test of the entire workstation (see Section A.1.1.). The results of the small chamber fabric tests shall be reported in emissions per unit area of fabric per unit of time ($\mu g/m^2\,h^{-1}$).

A3.2 Emission Limits

The results of each fabric emission test will be evaluated using a maximum emission limit for any specific chemical of 10 micrograms per square meter per hour ($\mu g/m^2 h^{-1}$). In addition, total emissions for any chemical class of compounds may not exceed one third the concentration values of Table 1 for classes of chemicals. (Note: The conversion from concentration limits to emission rates was done by using the mass balance equation in ASTM D5116-97 and the loading ratios for the office furniture systems. Thus, if the limit for a class in Table 1 is 50 $\mu g/m^3$, then the emissions for that class cannot exceed 50/3 or 17 $\mu g/m^2 h^{-1}$.)

SECTION B

OTHER REQUIREMENTS RELATED TO INDOOR AIR QUALITY

Each bidder shall identify the recommended maintenance, cleaning, refinishing, and disposal procedures and all associated materials for each major workstation component. Where chemicals are used in these procedures, an MSDS shall be provided for each chemical. Each bidder's product will be evaluated with preference given to the use of low or zero VOC products. The re-use or recycle potential of the product components at the end of the useful service life will also be evaluated. Finally, the ability of the product to reduce adsorption of VOCs and particles during its lifetime and the ease of cleaning VOCs and particles from the components will also be considered.

Preventive measures to reduce emissions of VOCs from workstations.
The following recommendations are made regarding the post-manufacturing handling of office furniture systems that are to be installed in a building.

[NOTE: Items 1 and 2 below are not part of the specification but will be included in DGS's operational and maintenance policy]

1. The State of California shall ensure that all office furniture systems be aired out off-site in a dry, well-ventilated space for no less than ten days at some point after the final stage of manufacture. This stage shall be considered complete after any inspection of soiling and the treatment and drying of the soiled materials. The ventilation rate in the space shall be no less than 1 air change per hour of outdoor air. The workstations shall be unwrapped and unpackaged during this air-out period.

2. Alternatively, if the above off-site airing out cannot be done, workstation installation shall be completed no less than ten days prior to building occupancy or space re-occupancy, where feasible. The ventilation rate in the building shall be no less than 1 air change per hour of outdoor air. Where workstations are being installed in an occupied space, the building must be flushed out continuously (i.e., 7 days/week, 24 hr /day) at the maximum outdoor air rate for at least ten days after installation.

3. Where the substrate for work surfaces, shelving, draw faces, or other components are composite wood products (panel products such as particleboard, medium density fiberboard, and plywood) that contain formaldehyde-based resins, the substrates shall be fully encapsulated on all six sides unless the 20 ppb formaldehyde requirement can be met without full encapsulation.

4. Holes drilled in the composite wood product components at the factory shall be supplied with plugs that can be easily removed when the holes are required for the assembly of the workstations and panels. Holes need not to be plugged if the adjusted chamber formaldehyde concentration is the below 20 ppb requirement as stated above.

Packaging

The State's goal is for all packaging to be diverted from landfills. As such, returnable and reusable packaging systems shall be considered.

Packaging shall be minimized to that required to adequately protect the furniture system components from mechanical damage or soiling. In addition, corrugated containers used for packaging shall contain a minimum of 35% recycled content paper fiber.

SECTION C

RECYCLED CONTENT REQUIREMENTS

Each modular furniture product and/or panel system shall be a recycled content product and all manufacturers shall provide information on recycled content as required by State law.

The California Public Contract Code (PCC) Sections 12205 and 12210, hereafter referred to as the State Agency Buy Recycled Campaign, states:

> 12205. (a) All State agencies shall require all contractors to certify in writing the minimum percentage, if not the exact percentage, of post consumer and secondary material in the materials, goods, or services provided or used. This certification shall be furnished under penalty of perjury.
>
> 12210. (a) Fitness and quality being equal, all local and state public agencies shall purchase recycled content products instead of non recycled products whenever available at no more than the total cost of non recycled products. All local public agencies may give preference to the suppliers of recycled products. All local public agencies may determine the amount of this preference.

A modular office system product shall conform to this specification through at least one of the following two test methods:

C1. State Agency Buy Recycled Campaign (SABRC) Method: A product may qualify as a recycled content product if it meets the standards set forth in the California Public Contract Code. The minimum content standards apply to eleven product/material categories, and each has a specific minimum content requirement (see Table C1). Note: SABRC reporting requires that the manufacturer report the minimum recycled content (i.e., including both pre-consumer and post consumer) for the determined source material contained in each SABRC product . For the purposes of documenting this specification, a completed Recycled Content Certification Form shall be submitted for each product line included in this bid. Furthermore, conformance with this specification means that all combinations of options and selections delivered to the State shall result in a workstation that meets SABRC requirements. See Appendix B of this document for the Recycled Content Certification Form.

METHODOLOGY: Modular office furniture products and panel systems are normally composites. Since SABRC accounts for recycled content purchases by individual material categories, it is necessary for a manufacturer to classify their composite product as a single material category. The manufacturer shall demonstrate compliance with SABRC requirements using a two step process:

1) The manufacturer shall determine the source material representing the greatest percentage of the product by either weight, volume, or cost.

2) The manufacturer shall certify that the product meets the minimum recycled content level for that SABRC material category.

If a product has recycled content levels meeting the SABRC requirement (see Table C1), then a state agency purchasing the product will be able to count it towards meeting the Recycled Content Environmental Specification for Office Furniture Systems through the SABRC Method. The predominant material type must be one of the 11 SABRC categories in order for the product to qualify. The following chart lists only the SABRC material categories that are commonly used in office furniture products:

Table C1. Relevant SABRC Material Categories

SABRC Material Type	Minimum Content Requirement %
Paper products	50% RC, 10% PC
Plastic Products	50% RC, 10% PC
Glass Products	50% RC, 10% PC
Paint	50% RC, 10% PC
Steel	25% RC, 10% PC
Index: RC=recycled content (secondary material, including post-consumer material) PC=post-consumer	

Relevant Definitions: See Appendix B: *State Agency Buy Recycled Campaign Manual, pages 23-25.* The manual can also be accessed on the world wide web at: http://www.ciwmb.ca.gov/buyrecycled/stateagency/

C2. Source Material Method (Alternate): The alternate method to conform with this Recycled Content specification is to meet the recycled-content criteria for key source material and major components as listed in Table C2-1 below. This method requires the manufacturer to meet all 9 of the listed recycled content criteria by category. The exception occurs only if a listed source material category is not used in the product in question.

METHODOLOGY: This specification allows each office furniture manufacturer to report the average recycled content and/or average post consumer content of each specified category by weight. Averaging of recycled content allows more flexibility than "minimum content reporting" and considers the variability of recycled materials over time. The calculation is based on the previous 12 month period from the date of the latest recycled content certification to the State of California. The preferred model shall be the Business and Institutional Furniture Manufacturers Association (BIFMA) Standard Office which contains lateral files, flipper doors, finish posts, panels, work surfaces, pedestals, tackboards, shelves, and low shelves (Reference: http://www.bifma.com/). The alternate recycled content specifications are listed by key material categories/components in Table C2-1 below. The formulas for calculating the percent of

recycled content for secondary source materials and post consumer source materials are as follows:

(S/T) x 100 = % SSM

Key:
SSM = Average secondary material for each material category
S = Total weight of the secondary source material used during the previous 12 months
T = Total weight of all source material used during the same 12-month period

(PC/T) x 100 = % PCSM

Key:
PCSM = Average post consumer source material for each material category
PC = Total weight of the post consumer source material used during the previous 12 months
T = Total weight of all source material used during the same 12-month period

DISCLAIMER: Conformance with the Source Material Specification is not evidence that a product meets the SABRC requirements.

Table C2-1. Alternate Specification for Modular Office Furniture Systems

Major Material Type/Component	Recycled Content of Source Material by Weight (Based on averaging method for previous 12 months)
Steel used for structural and non-structural panels and all other components	30% RC
Aluminum (all components)	15% PC
Paper fiber used for acoustical panel core, honeycomb panel core, etc. *	20% RC
Wood fiber (particleboard or MDF used for substrate, non-structural panels, or structural panels.)	90% of particleboard or MDF cellulose source material shall be farm-grown pulp trees, secondary wood waste from mill operations and/or post consumer urban wood waste or any combination thereof.
Tackable surface *	25% RC
Plastic fabric (made from either spun or filament plastic) used for covering vertical services of panel fabric *	Offer at least 6 selections that are at least 50% RC material, including 10% PC
Corrugated container used for packaging *	35% RC
Fiberglass Insulation (panel core)	30% PC
Plastic components (all plastic components except for panel fabric) *	15% RC
Index: RC=recycled content (secondary material, including post-consumer material) PC=post-consumer * Do not double count source materials used in distinct classifications of component categories.	

Relevant Definitions: See Appendix B: *State Agency Buy Recycled Campaign Manual, pages 23-25.* The manual can also be accessed on the world wide web at: http://www.ciwmb.ca.gov/buyrecycled/stateagency/

Verification of Claims

To verify a claim that a product meets the recycled content criteria listed in this specification, each manufacturer must provide reasonable access to production records and the right of access to production facilities on an unannounced basis. In the event that a component is furnished by a supplier, a letter from the supplier stating the recycled content shall be sufficient. In addition, all claims related to criteria contained in this specification must be certified by an Officer of the Corporation under penalty of perjury.

SECTION D

REQUIREMENTS FOR CFCs/HCFCs

No modular office systems shall contain plastic foam that is manufactured or formulated using CFCs (chlorofluorocarbon) or HCFCs (hydrochlorofluorocarbons). A signed certificate shall be submitted with bid documents indicating whether or not this requirement is met.

SECTION E

REQUIREMENTS FOR WASTE AUDITS

All modular office systems shall be manufactured at a facility that has established a program for solid waste auditing, has prepared a waste reduction plan, and has instituted a means to track progress towards waste reduction and diversion from disposal of materials such as metals, plastics, fabrics, wood, leather, fiberglass, and glass. A description of the this program and/or a copy of the most recent waste audit shall be submitted with the bid documents.

SECTION F

REQUIREMENTS FOR TASK LIGHTING

Task lighting can save significant amounts of energy when used in conjunction with lower general or ambient light levels. When it is done with articulated (swing arm) lamps, it has the further advantage of giving users control over their luminous environment and allows them to obtain the illumination levels and angles most suitable for their work assignments and individual preferences. Task lighting also creates an opportunity for individuals to select the color rendition of the lamps in their fixtures.

Studies of office worker reports of sick building syndrome symptoms have shown that prevalence of such reports is lower when occupants have control over important aspects of their work environment. Task lights, especially articulated task lights, provide such enhanced individual occupant control.

Requirements for Workstations
Workstation furnishings shall provide for the installation of articulated light sources including attachment and electrical power provisions.

The selected furniture manufacturer shall make adjustable arm task lights available as an option. Adjustable arm task lights shall meet the following specifications:

- Equipped with linear, circular, or compact fluorescent lamp technology
- Adjustable, fully articulated and balanced head and arms
- Cord set for plug in
- Wall bracket, panel bracket, table clamps or weighted table base options as appropriate for selected furniture systems and occupant needs.
- Built in reflector

Under-shelf task lights shall meet the following specification:

- Equipped with linear or compact fluorescent lamp technology
- Equipped with a shielding device that prevents direct glare into an occupant's eyes when the occupant is in a typical working posture
- Built in reflector

The selected furniture manufacture shall also make light colored furniture available as an option. A light colored panel fabric shall have a minimum reflectivity of 40%.

Requirements for Lamp Types
All task lights shall be equipped with linear or circular fluorescent, or compact fluorescent systems and shall meet the following requirements. The attached worksheet shall be filled out for both lamp types and submitted with the bid documents.

Requirements for Linear Fluorescent Lamps
All linear fluorescent lighting systems shall meet the following specifications:

- Minimum Color Rendering Index (CRI) of 75
- Option of common Color Temperature lamps (CCT) (2700^0 K through 4100^0 K)
- Minimum power factor of 97%
- Minimum system efficacy of 76 lumens per watt
- High frequency electronic ballast
- Maximum Total Harmonic Distortion (THD) of 20%
- Minimum lamp life of 15,000 hours

Requirements for Compact Fluorescent Lamps
All compact fluorescent lighting systems shall meet the following specifications:

- Minimum Color Rendering Index (CRI) of 75
- Option of common Color Temperature lamps (CCT) (2700^0 K through 4100^0 K)
- Minimum power factor of 97%
- Minimum system efficacy of 50 lumens per watt
- Electronic ballast
- Maximum Total Harmonic Distortion (THD) of 20%
- Minimum lamp life of 10,000 hours

WORKSHEET

List all lamp and ballast combinations with all of the following specifications. Use additional pages if necessary. Submit with bid documents.

LINEAR FLUORESCENT SYSTEMS														
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
BALLAST							LAMP							
Manufacturer	Model Number	Power Factor **97% Min.**	THD **20% Max.**	Ballast Factor	System Input Watts	Electronic Ballast (Yes/No)	Manufacturer	Model Number	CRI **Min. 75**	CCT ^{0}K	Rated Initial Lamp Lumens	Number Lamps In System	**E x L x M** Delivered System Lumens	**N / F** System Efficacy **Min 76 LPW**

COMPACT AND CIRCULAR FLUORESCENT SYSTEMS														
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
BALLAST							LAMP							
Manufacturer	Model Number	Power Factor **97% Min.**	THD **20% Max.**	Ballast Factor	System Input Watts	Electronic Ballast (Yes/No)	Manufacturer	Model Number	CRI **Min. 75**	CCT ^{0}K	Rated Initial Lamp Lumens	Number Lamps In System	**E x L x M** Delivered System Lumens	**N / F** System Efficacy **Min 50 LPW**

Glossary

ACH: air changes per hour, equivalent to the number of times the volume of air in the space is replaced in one hour by outdoor air

ASHRAE: American Society of Heating, Refrigerating, and Air-Conditioning Engineers

ASTM: American Society for Testing and Materials

BIFMA: Business and Institutional Furniture Manufacturers Association

CARB: California Air Resources Board

CEC: California Energy Commission

Corrugated Container: A container made of a pasted, single- or double-faced, multi-layered type of board in which the bottom or middle layer is fluted.

DHS: California Department of Health Services

HVAC: Heating, Ventilating, and Air-Conditioning

MSDS: Material Safety Data Sheet

OEHHA: Office of Environmental Health Hazard Assessment

PC: Post Consumer (see page 21 of appendix B, SABRC Manual for a definition)

Pre-consumer Materials: Material or byproducts generated after the manufacture of a product is completed but before the product reaches the end-use consumer. Pre-consumer material does not include mill and manufacturing trim, scrap, or broke which is generated at a manufacturing site and commonly reused on site in the same or another manufacturing process. Examples: Urban wood, wood waste/debris, non-yard wood, lumber waste, construction and demolition wood waste/debris, and agriculture and forest waste

PI: Postindustrial Materials -- Generally this is the same as pre-consumer materials.

RC: Recycled Content

SABRC: State Agency Buy Recycled Campaign

SumVOC – sum of each of the individual identified and quantified VOCs.

TVOC: Total Volatile Organic Compounds

VOC: Volatile Organic Compound

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Appendix A
List of compounds that must be quantified in measurement of VOCs at 96 hours
(European Commission, 1997)

Minimum number of compounds to be included in TVOC analysis

CHEMICAL CLASS/ COMPOUND	CAS No.	BOILING POINT (°C)
AROMATIC HYDROCARBONS		
Benzene	71-43-2	80.1
Toluene	108-88-3	111
Ethylbenzene	100-41-4	136.2
m/p-Xylene	108-38-3/106-42-3	139.1/138.3
o-Xylene	95-47-6	144
n-propylbenzene	103-65-1	159
1,2,4-Trimethylbenzene	95-63-6	169.4
1,3,5-Trimethylbenzene	108-67-8	165
2-Ethyltoluene	611-14-3	165.2
Styrene	100-42-5	145.2
Naphtalene	91-20-3	218
4-Phenylcyclohexene	31017-40-0	251-3[1]
ALIPHATIC HYDROCARBONS		
n-C6 to n-CI6		
n-Hexane	110-54-3	69
n-Heptane	142-82-5	98.4
n-Octane	111-65-9	125.7
n-Nonane	111-84-2	150.8
n-Decane	124-18-5	174.1
n-Undecane	1120-21-4	196
n-Dodecane	112-40-3	216.3
n-Tridecane	629-50-5	235.4
n-Tetradecan	64036-86-3	253.7
n-Pentadecane	629-62-9	270.6
n-Hexadecane	544-76-3	287
2-Methylpentane	107-83-5	60.3
3-Methylpentane	96-14-0	63.3
1-Octene	111-66-0	121.3
1-Decene	872-05-9	170.5
CYCLOALKANES		
Methylcyclopentane	96-37-7	71.8
Cyclohexane	100-82-7	81
Methylcyclohexane	108-87-2	101

CHEMICAL CLASS/ COMPOUND	CAS No.	BOILING POINT (°C)
TERPENES		
3-Carene	13466-78-9	167
alpha-Pinene_	80-56-8	156
beta-Pinene	181172-67-3	164
Limonene	138-86-3	170
ALCOHOLS		
2-Propanol	67-63-0	82.4
1-Butanol	71-36-3	118
2-Ethyl-1 -hexanol	104-76-7	182
GLYCOLS/GLYCOL ETHERS		
2-Methoxyethanol	109-86-4	124-25
2-Ethoxyethanol	110-80-5	118135
2-Butoxyethanol	111-76-2	231171
1 –Methoxy-2-propanol	107-98-2	118
2-Butoxyethoxyethanol	112-34-5	231
ALDEHYDES		
Butanal	123-72-8	76
Pentanal	110-62-3	103
Hexanal	66-25-1	129
Nonanal	124-19-6	190-2
Benzaldehyde	100-52-7	179
KETONES		
Methylethylketone	78-93-3	780
Methylisobutylketone	108-10-1	116.8
Cyclohexanone	108-94-1	155.6
Acetophenone	98-86-2	202
HALOCARBONS		
Trichloroethene	79-01-6	87
Tetrachloroethethene	127-18-4	121
1,1,1 –Trichloroethane	71-55-6	74.1
1,4-Dichlorobenzene	106-46-7	173
ACIDS		
Hexanoic acid	142-62-1	202-3

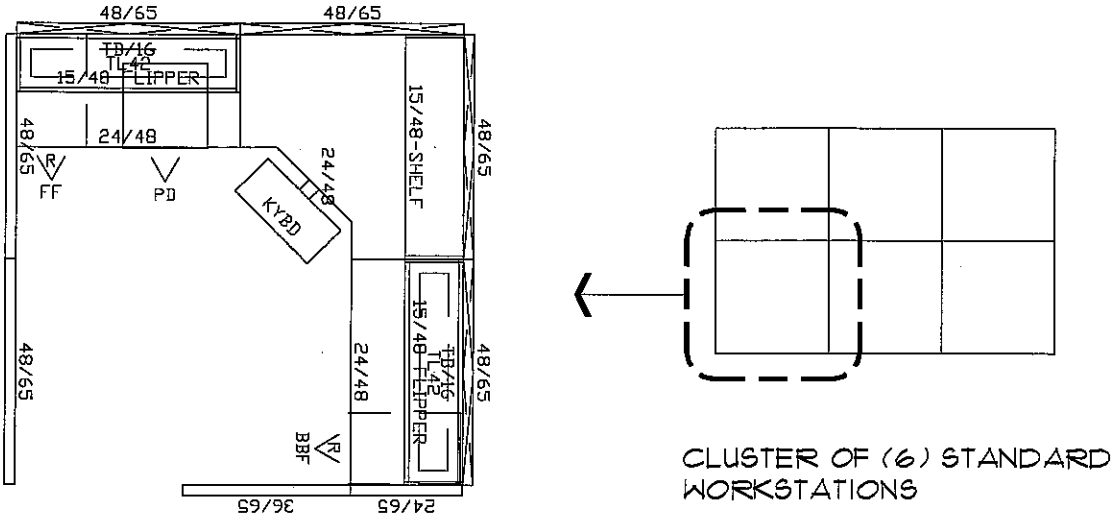
CHEMICAL CLASS/ COMPOUND	CAS No.	BOILING POINT (°C)
ESTERS		
Ethylacetate	141-78-6	77
Butylacetate	123-86-4	126.5
Isopropylacetate	108-21-4	85
2-Ethoxyethylacetate	111-15-9	156.4
TXIB (Texanolisobutyrate)	6846-50-0	
OTHER		
2-Pentylfuran	3777-69-3	>120 (2-tert-butylfuran)
THF (Tetrahydrofuran)	109-99-9	67

[1] value of 1-phenyl-cyclohexene

Attachment B. State Agency Buy Recycle Campaign (SABRC)
(submitted as a separate Word file; also available on the world wide web at:
http://www.ciwmb.ca.gov/buyrecycled/stateagency/

FIGURE 1

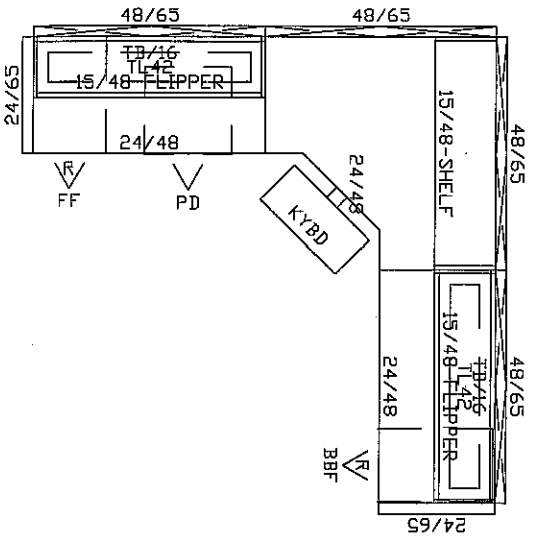
STATE OF CALIFORNIA'S STANDARD WORKSTATION



QTY	DESCRIPTION
4	48" X 65" POWERED PANEL (48/65)
2	48" X 65" NON-POWERED PANEL (48/65)
1	36" X 65" NON-POWERED PANEL (36/65)
1	24" X 65" NON-POWERED PANEL (24/65)
2	24" X 48" WORKSURFACE (24/48)
1	48" X 24" CORNER WORKSURFACE (24/48)
2	48" FLIPPER CABINET W/TASKLIGHT (15/48 Flipper)
1	48" SHELF (15/48 Shelf)
1	15" X 24" B/B/F PEDESTAL FILE (BBF)
1	15" X 24" F/F PEDESTAL FILE (FF)
2	16" X 48" TACKBOARD (TB/16)
1	PENCIL DRAWER (PD)
1	ARTICULATING KEYBOARD (KYBD)

FIGURE 2

STATE OF CALIFORNIA'S STANDARD WORKSTATION TO BE TESTED FOR VOLATILE ORGANIC COMPOUND EMISSIONS



QTY	DESCRIPTION*
4	48" X 65" POWERED PANEL (48/65)
2	24" X 65" NON-POWERED PANEL (24/65)
2	24" X 48" WORKSURFACE (24/48)
1	48" X 24" CORNER WORKSURFACE (24/48)
2	48" FLIPPER CABINET W/TASKLIGHT (15/48 Flipper)
1	48" SHELF (15/48 Shelf)
1	15" X 24" B/B/F PEDESTAL FILE (BBF)
1	15" X 24" F/F PEDESTAL FILE (FF)
2	16" X 48" TACKBOARD (TB/16)
1	PENCIL DRAWER (PD)
1	ARTICULATING KEYBOARD (KYBD)

* If sizes listed above are not available in your product line, substitutions are allowed as long as the total area of each surface is within 5% of those listed above.

The above workstation is based on the State of California's Standard Workstation in a 6-pack configuration. A 6-pack configuration consists of 118 linear feet of panels. Given that 56 of the 118 linear feet are shared between adjoining workstations, we have estimated the average linear feet of panels per workstation for IAQ emission testing purposes to be $118/6 \approx 20$ ft.